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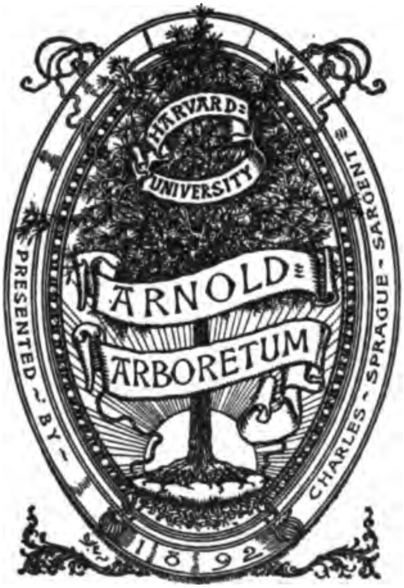

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A NOTE

UPON

THE "BEE-HOLE" BORER OF TEAK IN BURMA.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.

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A NOTE

UPON

THE "BEE-HOLE" BORER OF TEAK IN BURMA.

(DUOMITUS.)

I.—General.

FOR some years past Forest Officers and Timber merchants have noticed and reported that teak logs when cut up in the mill are occasionally found to contain holes and elongate tunnels of considerable size and roundish-oval in section, to which the popular name of "bee-hole" has been given. This name, so far as I can ascertain, appears to be a "trade" one and, as is often the case with popular nomenclature, is unsuitable since the holes have no connection whatsoever with bees. All teak timber is not affected in this manner, the trees in certain forests in different localities suffering more than those from others. Timber affected in this way is to be found all over Burma, but it is apparent that certain forests are more liable to contain "bee-holed" timber than others. For a considerable time the origin of these holes has been a mystery. It was attributed for the most part to an insect or insects, although various much wider surmises as to the cause have been advanced.

There are no two opinions, however, upon the damage done to the timber. Holes of all sizes are to be found right inside the large teak squares and greatly reduce the prices obtained for the wood or ruin it altogether. For instance "bee-holed" timber is quite useless for Admiralty purposes and attention was drawn to their presence in the wood in the early days of Forest operations in Tenasserim. In his Report on the Teak Forests of Tenasserim Dr. H. Falconer, F.R.S., Superintendent of the Botanical Gardens, Calcutta, made the following allusions to this subject as long ago as 1851 :—"The mixture of this light dead timber, with unseasoned logs which have been felled green and logs flawed with holes and clefts from the Thaungyin, in the shipments made to England is generally considered to have been the cause of the bad repute into which the Tenasserim teak has fallen at home for shipbuilding.........The two latter circumstances had more to do with the result than the first." "The tree during its growth does not seem to suffer much from the ravages of parasitical insects. Captain Tremenheere mentions that the stem is attacked by a beetle in the Thangyin which bores teredo-like holes. I observed no marks of such an insect in the Ataran Forests."

Captain Guthrie, Superintendent of Forests in the Tenasserim provinces, wrote in a report dated 20th June 1845, "Of the Thaungyin teak I may remark that I have seen it growing and thriving in every variety of locality; it has generally the advantage of carrying its girth well to a great height, not tapering quickly; it appears to be somewhat liable to small cells, isolated, but which appear in sawing up."

The presence of these "bee-holes" in the wood has resulted in two serious drawbacks :—

(1) Reduction in the amount of timber available for export owing to the trees from certain localities having been found to be badly "bee-holed." This results in smaller amounts being available in the home markets.

(2) Serious losses to the merchant engaged in extracting the wood.

Under the latter head I have been supplied with the following figures (at Moulmein) :—

			R	*a.*	*p.*
Value of good sound teak log, 24′ × 5′ middle girth free from bee-holes			160	0	0
Do.	do.	with a few bee-holes	92	8	0
Do.	do.	with numerous bee-holes	40	0	0
Do.	do.	entirely riddled	7	0	0

(The log would be cut up and sold as firewood.)

Soon after my arrival in Burma I paid a visit to the Saw Mills of Messrs. Steel & Co. in Rangoon, where the manager very kindly showed me a number of attacked squares and, in fact, teak material of all sorts. An exceptionally badly riddled square was cut up in order that the tunnels might be traced from the orifice opening out on the outer surface to their extremities in the wood.

Two points were ascertained:—

(i) That the tunnel curved up the stem soon after entering and ended in a slightly wider chamber at its upper extremity. Its section was oval-elliptical.

(ii) That the tunnel did not necessarily open on to the outside of the squares. In taking off slabs with a circular saw it became apparent that tunnels both commenced and ended within the wood itself.

From an examination of the tunnel it was at once apparent that, although the work of an insect, it was not the work of one of the carpenter bees (*Xylocopa*). These bees usually work in colonies, the tunnels being placed closely adjacent and being invariably large in section and circular. Nor was it the work of a wood wasp (Sirex); the grub of the latter tunnels in a very irregular manner in the wood, the gallery running at various angles, and, in addition, there is always an exit gallery bored straight from the pupal chamber to the outside. This reduced the matter to three probable groups. Two of beetles, *Buprestidæ* and *Cerambycidæ* and one of the *Heterocera* or moths (the wood-boring families *Cossidæ*, *Arbelidæ*, etc.).

From my examination of the tunnels I was inclined to think they were either Buprestid or Heterocerous. The difficulty, however, was that the tunnels, though varying in size, were each individually of the same width throughout. In other words, the whole tunnel appeared to have been made by the *full grown* insect; whether in its larval or mature stage had yet to be ascertained. I could find no trace of the gradually increasing gallery made by a larva as it grows from its young to its full-grown condition; nor did there appear to be any separate exit gallery. These facts rather led to the assumption that the insect was one of those which spend the whole of their grub stage (until full size is attained) feeding beneath the bark in the bast and sap wood, only boring into the wood to pupate, and this was a point to be evidently kept in view in studying the attack in the forest. The fact that the tunnels varied greatly in width was not of great importance since the individuals of many insects of one and the same species vary greatly in size, as also do the males and females of the same species.

The second of the above points was of great importance since it seemed to indicate that the tree had been attacked whilst alive and in a younger stage, the exit hole on the outside of the stem having been subsequently covered over by later layers of wood.

II.—Points to be studied.

My examination of the timber in Messrs. Steel & Co.'s Saw Mill enabled me to draw up the following questions which required answering from direct observations in the forest:—

(1) The exact position on the tree and direction of—

  (*a*) the entrance hole;
  (*b*) the main gallery;
  (*c*) the pupal chamber;
  (*d*) the exit hole;

(2) Where the eggs are laid.

(3) Length of time spent in the larval or grub stage and where and how the larva feeds.

(4) Length of time passed in the pupal or chrysalis stage and where this stage is passed.

(5) At what time of the year the insect quits the tree and how.

(6) The nature of the insect, whether wood wasp, carpenter bee, beetle (buprestid or longicorn) or a boring heterocerous (moth) caterpillar.

(7) Are green standing trees in the forest attacked?

(8) Are the trees only attacked after being girdled?

(9) Are dead trees attacked by the insect?
(10) At what age are the trees attacked?

III.—Tharrawaddy Teak plantation Thinnings.

"Bee-holes" in teak in the Tharrawaddy Division are said to be by no means common. We found, however, what Mr. Troup, the Divisional Officer, considered to be an example of such in an 1888 plantation in the Kadin Bilin Forest. In the light of subsequent investigations I am now able to corroborate Mr. Troup. This plantation had been thinned last year and the thinned trees were lying in the coupe, since the thinnings here are not sold. Whilst cutting up and examining one of these trees for *Scolytidæ*, with one or two species of which the wood was being riddled, we came upon a cavity or tunnel in the stem and traced it up to what appeared to have been a pupating chamber of an insect, situated in the long axis of the tree in the centre of the heart wood. The top of the tunnel or former exit hole of the pest had three rings of sap wood superimposed above it. It was therefore justifiable to suppose that the attack had been made upon the tree whilst still living, the entrance or exit hole having been closed up by the subsequent growth of the tree.

IV.—Examination of Timber from the Mohnyin Reserve in the Kadu Depôt, Katha Division.

On my arrival at Kadu in the Katha Division, Upper Burma, I examined a number of teak logs in the Depôt and also some standing dead girdled trees. The logs had all come from the Mohnyin Reserve, the teak trees of which were earning an unenviable notoriety owing to the number of "bee-holes" the timber contained. I found that a majority of the logs showed "bee-holes" on the outside as also sections of them on the cut ends. The holes were usually oval-elliptical in shape and appeared to vary greatly in size. Many were badly "weathered," the opening on the outside being much enlarged, the enlargement being due to either moisture or to the attacks of wood-peckers searching for the grubs. The holes were either widely scattered, only two or three appearing on the outside of a tree, or there were several closely adjacent to one another. A careful examination of the holes and the tunnels into which they led disclosed the fact that these latter invariably curved upwards soon after leaving the outside. As already seen in the Saw Mill at Rangoon, the diameter of the tunnel was the same all the way up with the exception that the last 2—2½ inches were slightly enlarged. I had noticed in the wood examined in Rangoon that this enlarged area was often lined with a layer of calcareous matter, but this was not the case with the galleries examined here.

V.—Examination of Standing trees in the Mohnyin Reserve.

(*a*) *Dead Trees.*

Dead standing trees in the forest exhibit much the same appearance as the felled logs. The "bee-holes" are to be seen on the outside often "weathered" and enlarged and are also to be found inside the timber when cut up, the end of the hole having been closed over by subsequent growth of wood. In no instance, however, have I found fresh attacks, *i.e.*, fresh "bee-hole" borings, in dead trees; the holes in every case in this latter having all the appearance of having been made some time previously.

(*b*) *Girdled and dying trees.*

It was perhaps but natural that in the first instance one should entertain the opinion that there might be some connection between the custom of girdling the green standing teak trees and leaving them several years in the forest before extraction and the "bee-hole" attacks. Whilst, however, my examinations showed me that standing girdled dying trees contained the "bee-holes" both outside and also inside the wood, I found no evidence to prove that the holes in the wood were made by insects attacking the trees after they had been girdled and whilst the bast and sap wood were slowly dying. In the case of the Sâl tree in India, and in fact of probably the majority of trees, girdling standing trees in the forest would almost certainly be followed by various species of wood-boring insects at once depositing their eggs in or beneath the bark and the resultant grubs would feed at first in the dying bast and sap wood and then, as they grew older, tunnel directly into the heart wood. The teak, so far as my observations go, appears to be an exception to this rule.

(*c*) *Green Trees.*

It was when I turned my attention to the examination of green standing trees in the Mohnyin Reserve that I commenced to understand the real position of affairs and to make the first of a series of observations which have led to the discovery of the true author of the "bee-holes" in teak, of their mode of origin and of a considerable portion of the life history of the "bee-hole" borer.

I have already shown that the "bee-holes" are to be found with their entire length and entrance (or exit) hole buried deep in the heart wood of the tree. We have also seen that quite small trees (16-year old), as instanced in the Tharrawaddy Plantations, may have a "bee-hole" in the wood entirely covered up by several later layers of sap wood. This led to the possible assumption that green trees were attacked by the author of the "bee-hole" and observations in the forest quickly showed that such was actually the case. Green trees showed the "bee-holes" on the outer surface of the bark in almost every stage of formation and age; the hole newly gnawed to the outside of the bark, from which sap was seen to be oozing and below which, either on projecting inequalities of the bark beneath the hole, or at the foot of the tree, saw dust and gnawed wood from the tunnel were to be found; older holes with the outer bark closing over them, the size of the external hole still present depending upon the age of the tunnel beneath; and finally trees in which the holes were entirely closed over, but which still betrayed, by the presence of a dark coloured or black point on the outside bark, the existence of a "bee-hole" beneath.

Once these outside evidences of the "bee-hole" have been fully recognised, the former presence or, as we shall see later, actual presence of this pest can be detected unerringly.

A discovery of a most serious nature was made whilst examining the trees in plantations in this reserve. It was proved beyond a possibility of doubt that the insect attacks trees of all sizes down to the youngest 2-year old sapling which contains at its base woody tissue.

VI.—The nature of the Insect which causes the "Bee-hole."

The discovery of fresh "bee-holes" in green trees led to the narrowing down of the possible authors of the damage and on splitting up some logs selected from a badly attacked green tree standing in the forest I obtained the "bee-hole" borer. It proved to be a large brightly marked caterpillar of the sub-order *Heterocera* or moths, thus discrediting its popular name of "bee-hole" and disposing of the much more probable theories that the holes were the work of one of the boring beetles belonging to the families *Buprestidæ* or *Cerambycidæ.*

VII.—The method of attack as determined from inspections of green, girdled and dead trees.

The egg is, I think, undoubtedly laid by the moth upon the bark,* or under a flake or ridge. If more than one egg is laid at any one spot only one develops, or, if more than one, the young caterpillars separate and bore into the bark at different spots. This is borne out by the fact that only one insect is found occupying the "bee-hole." The young larva on hatching out bores through the bark and feeds probably at first only in the bast, but later on, when its mandibles (biting-jaws) have become stronger, it eats into the sap wood as well. It bores an irregular shaped gallery having several irregularly-radiating arms, the total length being usually about four inches, with a breadth of three inches. As the grub becomes older it eats down into the sap wood, the depressions in the latter being deeper in the central part of the irregular shaped cavity. When full grown it bores into the heart wood and excavates a tunnel which curves upwards, is about nine to thirteen inches in total length, and is slightly enlarged at its upper end, the enlarged portion being from 1½ to 2 inches in length. This tunnel appears to usually start from the centre of the irregular depression, is of but slightly larger section than the body of the caterpillar and has the same width throughout, except at the upper end. The enlarged portion at the top is the pupating chamber and in it the caterpillar changes to the pupal or chrysalis stage, turning round so as to face ***down*** the hole before doing so. The tunnel is kept quite free of wood sawdust and excreta, these being ejected from it through a hole gnawed in the bark just over the entrance of the tunnel into the wood; the hole really forming a prolongation of the latter, but separated by the deep irregular depression in the sap wood. Before finally pupating the caterpillar again crawls up the tunnel and spins a close firm taut silken mesh across the tunnel just below the spot at which it opens out into the depression in the sap wood. It then proceeds backwards up the tunnel and spins a second of these meshes just below the point where the gallery opens out into the wider pupal chamber. The damage this insect does to the tree is then complete and the "bee-hole" in the wood has been made. An examination of all trees containing "bee-holes" on the outside will show the irregular depression in the sap wood. If the tree is dead, this depression may be considerably "weathered," but it is always distinguishable. If the tree is green and the external hole is nearly closed up, on shaving off the bark at the spot the layers of bast gradually closing over the depression and hole will be disclosed and beneath these the irregular depression with the entrance to the tunnel at or near the centre.

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* Since writing this, whilst inspecting the Shwegyin Plantation on the Salween river in Tenasserim, a patch of eggs which *may* prove to be those of this insect was discovered on the stem of a green teak. These eggs were flat, roundish and yellow, some 150 in number and laid close together in a blackish gummy substance which glued them on. Two moths had already issued from trees in this plantation. These eggs were taken on March 11th.

VIII.—Description of larva (caterpillar), pupa, chrysalis and moth.

Larva.—A large robust caterpillar consisting of a head and twelve segments; the latter swollen and distinct, skin shining with a satiny lustre. It tapers both anteriorly and posteriorly, the 12th or last segment being much smaller than the rest. Head small, shining, dark walnut-brown above and on sides; mouth parts black. First thoracic segment (the segment following the head) shining, light walnut-brown dorsally, with a truncate ovalshaped patch behind set with asperities and protuberances (probably to enable the grub to push out wood-dust particles from the tunnel); 2nd segment white with three tubercles placed transversely on each side of the dorsal median line; rest of segments to 11th inclusive satiny-white, with a broad transverse bright pink band on each, commencing just below the front edge of the segment and extending to about its middle; a large brown spot (spiracle) with a pink centre on each of the segments 2-11 (inclusive), just above the median lateral (side) line; 12th segment small, pink in front and a dirty-brownish black behind. A round black spot above and below each spiracle. Four small brown spots dorsally on each segment; two in the centre of the pink band one on either side of median line and the other two anteriorly on the white band set slightly laterally to the ones above them. These spots seem to partake of the nature of minute tubercles and may help the larva in its movements in the tunnel. Length 1¾ to 2 inches. All the segments with the exception of the 12th shining, with a satiny lustre. Under-surface satiny-white, as also are the three pairs of front legs (on the first three segments behind head) and the abdominal ones, the latter with well-marked clasping pads. Under-surface is flat, upper convex.

Pupa.—Stout, elongate, tapers slightly posteriorly. Chestnut-brown, darker at thoracic end; antennæ and wings of future moth distinctly visible as raised lumps on the pupal skin at the upper end. Colour lighter posteriorly; the abdominal segments canary yellow beneath and at sides, with narrow bands of this colour marking the intervals of the segments. The spiracles prominent as brown spots on sides of abdominal segments. Under-surface lighter in colour, length 1½ to 2½ inches.

Moth. – A large moth with long and narrow wings. The head thorax and body pale ochreous brown, more or less suffused with black; patches of black scales at each side of hinder portion of thorax. Fore wing pale ochreous brown with blackish streaks and an irregular whitish patch in the outer angle which tails off in a series of decreasing spots. Hind wing fuscous, slightly marbled with black. Expanse of wings 4⅛th inch.

The moth does not appear to have been taken in Burma since Hampson in the Fauna only gives the habitat as Sikkim; Nias; Ceram.

IX.—Probable Life History.

The egg is almost certainly laid upon the bark of the tree probably in the hot season before the monsoon bursts (*vide* footnote on p. 8). The caterpillar probably hatches out within a short period and feeds as I have shown in the bast and subsequently on the sap wood, finally pupating in the interior of the wood. It is probable that it only spends the monsoon months (with perhaps a portion of the preceding hot weather) in feeding and attaining its full size, and towards the commencement of the cold weather it tunnels into the tree. These conjectures are borne out by the fact that no half grown or smaller larvæ have been found in the irregular depressions beneath the bark and therefore it would appear that the insect passes through the whole of its life cycle from egg to moth in a year. Since a number of larvæ were found at the end of February at the top of the tunnels in the wood, but only one pupa, it appears that the cold weather is passed through in the larval stage in Upper Burma, perhaps partly in boring the pupating tunnel and chamber, and that the larva only changes to the pupal or chrysalid condition on the approach of the hot weather. I do not know as yet how long is spent in the pupal stage nor when the moth issues in Upper Burma, but the former is probably short, the latter issuing sometime during the hot weather. To enable the moth to issue, the pupa would work its way up the tunnel by means of the minute circles of spines situated on each of the abdominal segments, rupturing the mesh nets spun across the tunnel near its upper end and near the mouth in its progress, and projecting, for about half its length from the hole bored by the larva in the bark.* The moth probably issues at night and flies and pairs at night. The life history will vary slightly in Upper and Lower Burma and again in Tenasserim.

X.—Enemies.

As far as my present observations have been carried, the chief enemies of the "bee-hole" borer would seem to be wood-peckers. I noted two species in Katha: the one blackish-green, the other greyish-green.

They are both called *Thit tauk lauk* by the Burmans. These birds "tap" the "bee-hole" tunnels by boring down through the wood, above the exit hole on the bark, until they reach the tunnel and the grub which is to be found at the end of it. They exhibit the most wonderful instinct in this operation, as they appear to know that the end of the tunnel will be between 9 and 12 inches above the exit hole on the bark and bore in accordingly at this distance. It is probable that these birds exert a considerable check upon the increase of the insect, but their help in this respect can scarcely be called desirable, since they, in addition to often considerably enlarging the exit holes of the borers, drive other and larger holes into the wood, these holes being subsequently covered over and concealed by the growth of fresh outer layers of wood or, owing to "weathering," causing decay and rot to set up in the timber.

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* *Note 1.*—Since the above was written some teak areas and plantations on the Salween River have been visited in company with the Conservator. We inspected the Shwegyin plantation and searched for the borer. Mr. Manson pointed out something protruding from the bark of one of the trees about eighteen inches up from the base. An examination at once disclosed the object to be an empty pupal case and a closer examination enabled me to determine it as the pupal case of the "bee-hole" borer. It was in position as described above. The chrysalis case was quite fresh and the moth must have issued some time within the previous 48 hours. Another larger one, probably that of a female, was discovered in the plantation. The discovery points to the fact that the moths leave the trees in Tenasserim as early as the middle of March and probably on through a portion of April. Since the rains commence here in May, this was what might have been expected. I have already alluded to the fact that a patch of what may prove to be the eggs of this insect was discovered on bark of one of the trees in this plantation.

Note 2.—Portions of the stems of three teak trees containing living larvæ and a pupa *in situ* in the "bee-holes" were taken from the Mohnyin Forest to Rangoon and from there on my departure from Burma a month later to Calcutta. My object was to endeavour to breed out some moths and thus to identify the insect which I was of opinion would prove to be a species of *Duomitus*. This is always a difficult operation, since the wood as soon as cut commences to dry and the larva or pupa either dries up and dies or owing to the contraction the pupa is unable to make its way up the tunnel to allow the moth to escape. Mr. Nelson Anandale, Deputy Superintendent, Indian Museum, kindly undertook to look after my specimens for me until my touring came to an end. I have received a communication from him informing me that a moth issued during the first days of June and proved to be *Duomitus ceramicus*, Wlk.

XI.—Results of the attack to the timber.

Three classes of damage are caused to the timber as a direct result of the attacks of this pest.

(*a*) *Faults in the Timber.*

Since the caterpillar attacks and feeds in the bast and sap wood of green trees and that these trees still continue their growth after the pest has matured and left by the exit hole, the deep irregular depressions in the sap wood become gradually covered over by succeeding layers of wood until they are completely buried within the timber. There is, however, often a fault between the superimposed layers of the wood and the layers below them at the place where the irregular depression occurs, the intervening layers of wood having been eaten away by the caterpillar and a proper junction of the new layers not having taken place.

(*b*) *The "bee-holes."*

It is scarcely necessary to describe these further. We have already seen that their presence may be apparent on the outside of the timber in the form of the exit holes of the insect, or the tunnel and exit hole may have become entirely enclosed within the wood. In the case of badly attacked trees, *i.e.*, trees which have supported numbers of larvæ in successive years almost all through their lives, the timber is so riddled and contains so large a number of "bee-holes" and tunnels that it is almost entirely worthless for any purpose save that of firewood. The losses thus occasioned are serious and are of course aggravated by the fact that it is not always possible to tell whether a log is "bee-holed" or not. This latter would seem to be due to the fact that in some localities the insect confines itself to the younger trees, and thus by the time the tree has attained a felling size, the whole of the evidences of the former presence of this pest in the tree have become buried within the wood and will only become apparent when the log comes into the saw mill and is cut up.

(*c*) *Wood-peckers.*

Although these birds are present in the forest in the guise of friends, their attacks on the trees are to be feared almost as much as those of the insect. We have seen that they bore conical-shaped holes down into the wood to get at the grubs and, although in this way they diminish the number of the latter which will reach maturity, the result of their action on the timber is serious, this being more especially the case with the younger trees. In the case of these latter these large holes either become enclosed inside the wood and are thus hidden in what appears to be a fine sound log or they "weather" badly and, under the influence of water and fungi, set up rot in the wood. In either case their action is most detrimental to the timber.

XII.—Results of the attack in the Forest.

(*a*) *High natural Forest.*

Further observations are required before one can discuss with profit the real extent of the damage done by the insect in the Burman Teak Forests. From information already given me and from my own observations it appears to be much more plentiful in some localities than in others and in fact to appear to have had a preference for the trees of certain areas, whilst others are almost free from it. I say "to have had" since the evidence which has been gathered upon the "bee-hole" borer in the past has been entirely taken from old trees in the forest (as evidenced by external exit holes) and sawn logs in the various mills. From this latter evidence it would appear that trees are rarely killed by the insects, since trees whose timber has subsequently been found to be almost entirely riddled through right down to the heart (by successive insects over a long series of years) have been able to reach a great size and therefore age.

I am at present engaged in obtaining statistics on the subject of the distribution of the pest as represented by the different degrees in which the forests are infested, together with particulars as to the aspect, soil, rainfall, etc., of these localities.

In the Mohnyin Reserve I have seen trees of 9 inches diameter with as many as nine "bee-holes" in the lower 8 foot of the bole: several of these had been subsequently enlarged by wood-peckers. In addition, there were also one or more large wood-pecker holes, made by the birds in extracting the grubs. It may be taken as certain that forests containing such evidences of the presence of the pest will be found to have the timber of their old mature trees badly riddled.

From observations made on logs in the Kado Timber Depôt at Moulmein and information supplied it appears that areas in the Thaungyin Reserves of the Division of that name and the Sinswe Reserve of the West Salween Division are badly infested with the borer. The Ataran Forests, on the other hand, appear to be comparatively free from the insect.

(*b*) *Plantations.*

From the short investigations I have already been able to make upon the results of the attack of the caterpillar in plantations in the Mohnyin Reserve in Katha and in the Shwegyin plantations on the Salween river, it is possible to state that this pest is, in localities where it is abundant, probably one of the most serious the Forester has to deal with at present in Burma. It will apparently attack saplings from two years of age and upwards, and the state to which a plantation can be reduced by its attacks is almost incredible. The following is a description made of the present position of a portion of an 1896 plantation in the Mohnyin Reserve. In this particular forest the insect appeared to be very abundant, and probably from 40 to 50 per cent. (and I think the estimate is below the mark) of the trees in the area inspected showed the present attacks or results of past attacks of the caterpillar. Some of the young trees have several holes in them and in many cases wood-peckers have increased the size of these or bored fresh ones to get at the grubs: *e.g.*, one tree had been attacked by three borers and in each instance a wood-pecker had bored in above the "bee-hole" with the result that the stem already contains six holes, the tree being still under ten years of age. This portion of the plantation must, I think, already be looked upon as ruined by the insect, and yet I have been unable to find any reports of its attacks in the reserve journals. If the trees are allowed to remain on the ground, the holes will gradually become closed over and thus concealed within the wood. The timber of such trees will, however, be worthless. Several caterpillars were cut out of trees in this plantation. In another two-year old plantation in this forest a caterpillar was taken from the base of the stem of a young sapling, up the centre of which it had bored its pupating tunnel.

In the Shwegyin plantation on the Salween river the borer was found to be present. Fifteen comparatively fresh "bee-holes" were counted in the trees on this area and from evidences on the stems it appeared probable that the trees contained other closed over, or almost closed over, ones. Two empty fresh pupal cases were taken from trees.

In plantations visited at Thaubya (1902) and Natchoung (1889, 1891, 1900 and 1902) on the Ataran river no trace of the borer was visible, although a careful search was instituted.

With such evidences of the powers of this pest for injury before one it may be suggested that careful statistics are required as to the localities where the insect is at present abundant, and that plantations in such localities should not be created unless the necessary constant supervision required to keep the insect from obtaining a footing in them is possible.

XIII.—Proposed steps to be taken to clear the plantations.

In the present state of the investigations into the habits and action of this pest (although when the observations in this note have been confirmed and the moth obtained* we shall know all that is required to endeavour to combat it practically) it is too early to say what measures can be taken to endeavour to reduce its numbers in the forests. We are in a position, however, to suggest certain steps which should be taken to clear it out of the plantations and to endeavour to keep it out in the future. It may be stated at once that constant supervision will be necessary since we have seen that the pest does not apparently confine itself to any particular age or size of tree, the only desideratum being that the tree should contain a certain amount of hard wood into which the caterpillar can tunnel in order to pupate. This constant supervision will not be so difficult to maintain, provided the establishment permits of it (and this must be pre-supposed since it is useless forming the plantations only to have them ruined at the very outset by the borer), since I found that the Burma coolies employed at Mohnyin had a considerable knowledge of natural history and once they were shown what was required became quite adept at searching and finding trees containing "bee-holes" with living larvæ in them. It has been shown that the caterpillar feeds under the bark until full-grown and that on attaining full size it has to bore a hole through the bark to the outside so as to be able to eject through it the sawdust resulting from its tunnelling operations in the wood. A careful inspection of the trees at this period would enable the position of boring larvæ to be ascertained and they could be removed *before* they had bored down into the wood.

(ii) Again, it is probable that whilst the caterpillars are feeding under the bark their presence will be visible from the outside by sap oozing down on the bark from the spot at which they are working. If this proves to be the case, it will be possible to kill them off at a still younger stage.

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* *Vide* footnote No. 2 on page 12.

The above will mean that a close supervision over the plantations must be maintained through the rainy months, and whether this supervision has or has not been maintained can always be checked by visiting the plantations in the cold weather and seeing whether there are fresh "bee-holes" on the trees. Should this be found to be the case, the supervision there has been slack.

(iii) In the matter of badly infested plantations all badly attacked trees should be cut out; this operation being carried out, however, in the cold weather when they will be certain to contain all the caterpillars from the eggs laid in the previous season.

(iv) In localities where from the evidence in the forest the insect is known to be plentiful I would deprecate the formation of pure plantations of teak, it being probable that mixed ones would be much less liable to attack.

(v) Some attention should be paid to the wood-peckers with the object of preventing them attacking infested trees in plantations. In the Mohnyin Reserve these birds were very plentiful, and the damage they are doing to the young trees is too serious to be disregarded. When they attack the tree with the object of getting out the grub, the latter has committed all the damage he is going to do and therefore the wood-pecker, as far as the particular tree is concerned, only makes matters worse. In the interest of the timber it cannot be held that the bird counterbalances the evil it does by the number of insects it destroys, thus preventing them coming to maturity and reproducing themselves.

XIV.—Further observations required in the Forest.

Some of these have already been alluded to under XII. Amongst the most important is a confirmation, by officers stationed in different parts of Burma where "bee-hole" timber is plentiful, of the life history of this pest, as sketched above.

An answer is also required, if possible, as to the reason for the stated fact that the insect is more abundant in some localities than others. How do these localities differ from neighbouring unaffected ones? A very careful inspection of all plantations in the country is necessary with a view to ascertaining whether they are attacked by the pest and, if infested, whether badly; for if the latter, they are only serving as so many centres from which the insect will radiate outwards and spread into unaffected areas.

XV.—Points in the life history requiring further observation.

A confirmation of the life history as ascertained in the Mohnyin Forest in Katha, and to a lesser extent in Tenasserim, is required from officers in other parts of Burma, and in addition we require to know—

(1) When the moth leaves the tree in Burma (excluding Tenasserim) and how long it lives.
(2) Where it lays its eggs. Does it lay more than one? If so, are they laid singly or together? If singly, are they laid on the same tree or on different ones?
(3) When do the eggs hatch out?
(4) How many months does the caterpillar spend—
  (*a*) feeding in the bast and sap wood;
  (*b*) in boring the " bee-hole " (tunnel and pupating chamber) in the wood;
  (*c*) in the pupating chamber before changing to the chrysalis stage.
(5) How long is spent in the chrysalis stage?
(6) The different localities in Burma in which the insect is to be found.

G. I. C. P. O.—No. 935 R. & A.—19-7-1905.—1,700.—P. M. M.

A NOTE

ON

THE QUETTA BORER.

(ÆOLESTHES SARTUS.)

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.

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THE QUETTA BORER.

(*ÆOLESTHES SARTUS*, SOLSKY.)

I.—General.

FOR some years past it has been apparent that the trees of the avenues and private gardens in the station of Quetta were subject to the attacks of a boring insect. The pest has been given the rather appropriate local name of the " Borer."

The operations of this insect have latterly become so evident and so many trees have been killed or reduced to a dying condition that serious alarm has arisen for the safety of the tree-growth of the station as a whole, with the result that considerable attention has been recently focussed upon the pest. The Honourable the Agent to the Governor General called for a report upon the subject in 1904 and the Superintendent in charge of Arboriculture was ordered to draw up a note upon the borer. Whilst this note is of considerable interest, it is perhaps based rather too closely upon the life history of a beetle (known as *Apriona Germari*)* belonging to the same family (the *Cerambycidæ*) of beetles as does the Quetta borer. The *Apriona* feeds in mulberry at the Shahdera plantation near Lahore. Curiously enough, mulberry is one of the trees the Quetta borer has not attacked. It may be stated at once that the methods of attack of the Shahdera and Quetta borers are quite different and that there is no connection of any kind between them, nor does the latter bear the name of *Apriona Germari*.

During a visit paid to Quetta towards the end of May and beginning of June of the present year the life history and methods of operation of this beetle were studied in detail, and as a result it has become possible

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* Departmental Notes on Insects that affect Forestry, No. 1, page 25.

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to draw up the present note. I may preface my remarks by saying that the scale upon which this insect is carrying on its operations in the Quetta trees is quite unprecedented. No records are extant of any former infliction of like magnitude, or of anything approaching it, in an Indian station. As far as records go, it is quite unique. The longicorn (or long-horned) beetles, as this family is called, are more essentially inhabitants of woodland areas, but even in forests there are at present but few recorded instances of species having increased in such numbers as to commit serious depredations and none in India of their having gained the complete mastery over the trees of the forest. The fact that it appears to be an insect of unusual vitality and hardiness but adds to its power for harm.

II.—Origin of the Avenues, etc., in Quetta and Present Method of Supervision.

The first planting in Quetta appears to have been initiated in the Civil Lines by Mr. Bruce as far back as 1878. A year later Mr. Ingle joined as Treasury Officer and Cantonment Magistrate and continued the work both in the Civil Lines and Cantonments. Later on, after the evacuation of Kandahar, the work was taken up in a more serious manner and upon a larger scale by Mr. (now Sir Hugh) Barnes, at the time Political Agent of Quetta-Peshin. Several camel-loads of Chinar and other cuttings were procured from Kandahar and were put out on the main roads, the former notably on the Lytton road, where they and subsequent additions now form a very fine avenue, giving a deep shade. The late Colonel Gainsford was associated with Sir Hugh in this work, a Tree Committee being formed. The result has been to provide Quetta, *i.e.*, the Civil Lines and the lower portion of the Cantonment (all that then existed), with a series of beautifully shaded roads which form a marked contrast to the barren sterility of the surrounding stony hills and the major portion of the plain.

At the present time these avenues are under the supervision of three different agencies. The avenues planted with provincial funds are under the management of the Superintendent of Arboriculture; those within municipal limits under the Secretary to the Municipality, whilst the Cantonment area is naturally under the supervision of the Cantonment authorities. This divided control, especially in the Civil Lines, perhaps renders efficient protective work rather difficult. To it and to the absence of any one with the requisite special training to supervise effectually such important work must, I think, be attributed in great part the present lamentable condition of the trees in the station, over which the borer has succeeded in obtaining an almost complete mastery. It might be suggested that, should it prove feasible, it would be advantageous to place the whole of the Civil Lines under an officer who has had a special training in this class of work. It is probable that the Cantonment authorities would be glad to also avail themselves of the advice of such an expert.

III.—Origin of the Borer—Period at which its attacks were first noticed.

I have endeavoured to ascertain the locality from where this pest originally came. My own theory was that it probably existed in the white poplars and Kabul willows growing in this part of the country before the advent of the British to the site of the present station of Quetta. This theory I have found invariably supported by the villagers living in the vicinity of the station. Careful enquiries instituted in the villages with the aid of the Political Agent, Forest Officer, and Tehsildar elicited the information that the white poplar, Kabul willow, apricot, and mulberry were all to be found on the Quetta plain in a few scattered villages when the British first arrived. The first plantings in the station were mostly, if not entirely, made from cuttings, and if some of these were originally brought from Kandahar, a perusal of the life-history of the pest will make it obvious that the insect was not introduced with these.

It is probable that the pest got into Quetta either—

(1) By flight. The beetles on issuing from the trees in the neighbouring villages would not be long before they discovered such a favourable situation for their egg-laying operations as that provided by the avenues of pure white poplar and Kabul willow (their two favourite trees), planted in the Station; and the lopping of the lower branches of these trees has constantly provided them with fresh wounds at which to lay their eggs.

(2) From the poplar and Kabul willow firewood brought into Quetta in the early days to be used as fuel by the troops The life history shows that once the larvæ have got down into and pupated in the wood, the felling and splitting up of the tree, provided the pupal chambers in it are not split across, will not prevent the beetles issuing to pair and lay eggs in due course.

It is quite possible that the beetle may have been introduced in both these ways. Its at present great abundance must be attributed directly to—

(*a*) the planting of pure avenues of its chief food trees;

(*b*) the lopping of the lower branches, leaving open wounds on the trees.

Several of the European gentlemen in the station hold contrary opinions as to the first introduction of the pest. I have been informed that no villages existed previous to our arrival at Quetta, and that no white poplar were to be found on the Quetta plain at that time, the first having been brought from Afghanistan. It was held that the insect originally came from the Kabul willow, which existed all over the country. This latter opinion corroborates my theory that the insect was indigenous to the locality when the avenues were first planted, and that it is not a subsequent importation. These gentlemen also informed me that all the firewood for the troops was at first brought from Afghanistan.*

With reference to the point as to when the attacks of this pest were first noticed in Quetta, it would appear that attention was first drawn to its increasing numbers and to the evident destructive nature of its operations in the trees some two to three years ago. As a result of the report upon the subject called for last year, steps were taken this spring to collect the living beetles as they issued from the trees. Put into force several years ago, this method might have proved effectual. The attack has, however, got beyond all hope of it now proving a sufficient or efficient remedy and more drastic steps will have to be introduced if the beetles' hold over the trees is to be disputed and put an end to.

IV.—Description of the egg, grub, pupa, and beetle.

Egg.—The egg is milky-white in colour, elliptical in shape with pointed ends and from $\frac{1}{8}$th to $\frac{1}{6}$th inch in length. Plate I, figs. 1 and 2, show the eggs.

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* Mr. C. J. Gahan, of the British Museum, who very kindly identified the borer for me, wrote as follows: "It is an addition to the Fauna of British India, as it has previously been known only from Turkestan and Tibet." I expect it will be found throughout Afghanistan. It will doubtless seem strange to many, and is undoubtedly a strong argument in favour of the importance of the study of economic entomology in India, that a beetle as common as the Quetta borer should never have been reported as a member of the Fauna of British India.

Larva or Grub.—When first hatched out, the larva is a small grub about ⅛th inch in length ; the head is brownish with small black mandibles (biting jaws) and yellow body. After a few days the body segments become a dirty black in colour. The full-grown larva is a large, thick, yellow to yellowish white grub as much as three inches in length and ⅝th inch across at the upper and broadest end. The colouration is sometimes almost orange in tint. It consists of a head followed by 12 well-marked segments, the hinder ones being more deeply constricted than the four front ones. The head is small, black, the base being brown; the mandibles (biting jaws) black and powerful. The segment following the head is very much enlarged, as are also the following two; from the latter the segments gradually taper backwards, the last being about half the width of the first and bluntly pointed; a narrow somewhat elongate brown spot (the spiracle or breathing opening) is situated on each side of the 2nd and 4th to 11th segments ; a pair of minute legs are present on the underside of each of the 1st three segments following the head. Plate I, figs. 3, 4 and 5, show a young grub, a grub ⅓rd grown and a full sized larva.

Pupa.—The grub changes into a white or whitish-yellow object bearing some resemblance to the future beetle. It is, however, broader and quite soft. The legs, wings, and antennæ (feelers) of the future beetle can be seen pressed against the body; as they grow longer, the wings are seen to be curved round so as to lie on the breast of the pupa; the legs are pressed tightly against the lower surface and the antennæ are pressed close to the sides. Gradually as these parts reach their full development, the beetle is seen to have acquired its adult form. Size of a female pupa 1¼ to 1¾ inch in length by ⅜ to ⅝ths across body. Figs. 6 and 7 show a ventral and side view of the pupa.

Beetle.—The perfect beetle may be found in the tree several months before it is ready to issue. It is then light yellowish-brown in colour and all its outer parts are still soft. As these gradually become hard and firm, the colour darkens to the normal black or brown. When the beetle issues from the trees, it is elongate cylindrical, silvery grey in colour, with very long brown to black antennæ and long well-developed dark brown legs; the head is inclined forward at an angle and is furnished with a pair of powerful black mandibles; it is black in colour covered with a short, irregular, yellowish pubescence; the eyes are black, placed at the side of head and interrupted by the antennæ which are inserted in the upper part of the eye, the latter being prolonged round the base; the antennæ consists of 11 long joints, the bottom one being very much thicker than the others; the lower joints are swollen at the tops, where they are covered with short hairs. The thorax (the segment following the head) is broadest across the middle, the upper and lower margins are wavy, and the upper surface is covered with irregular ridges and protuberances. The elytra or wing covers are black or dirty olive in colour and are constricted behind; they have marked "shoulders" at the base, the sides are slightly curved inwards at the level of the middle pair of legs; the surface of the elytra is thickly coated with a glistening silvery or satiny-grey pubescence in life which has a remarkable sheen; the tip of the abdomen is left exposed by the elytra. The under-surface of head is black; rest covered with a yellowish to silvery grey pubescence which also thickly clothes the legs. Length $1\frac{3}{8}$ to $1\frac{11}{16}$ inch. Fig. 8 shows a male beetle.

The female differs from the male in having antennæ which do not reach to the end of the body, whereas in the male they are nearly twice the length of the insect. Thus the antennæ alone at once distinguish the female from the male. The exposed part of the last abdominal segments is covered with longish yellow hairs.

It will be found very often that beetles taken on the wing or from the bark of trees, etc., sometime after they have left the tree, will have lost some of the distinguishing silvery grey pubescence from the upper surface of the wing cases which then show black with a faint violet sheen, or they may be dull olive green.

The female is provided at the extremity of the body with an ovipositor of three joints. This ovipositor is held withdrawn into the body except when used for depositing the eggs. Length $1\frac{1}{4}$ to $1\frac{5}{8}$ inch. Fig. 9 shows a dorsal and side view of the female.

V.—Life-History.

The beetle was first noticed in the station this year (1905) on May 6th, the greater number of adults issuing between this date and the end of the month, after which there was a considerable decrease in the numbers coming out from the trees. These practically ceased by the middle of June (*vide* Appendix).

The egg stage.—The eggs are laid in small clumps of from 5 to 8 or 10 together at wounds, such as are left at spots where branches have been lopped or at other places on the bark, from which the sap is oozing. The beetle evidently seeks for such spots to save herself trouble since, if they are not available, she has to gnaw down through the bark until she reaches the sappy inner part before the eggs can be laid. This is necessary as the young larvæ require this substance to feed upon as soon as they leave the egg. The number of eggs laid by the beetle appears to be about 50, this number having been taken from the bodies of females on several occasions. Scattered eggs have been found in the sappy bark, but the system ordinarily followed is apparently to lay the eggs in clumps. The time spent in the egg stage is a short one, probably from ten days to a fortnight at most; eggs were found by myself in the latter part of June in considerable numbers in the trees and also young newly hatched out larvæ. The period passed in the egg stage is short, probably at most from 10 days to a fortnight, as young larvæ half an inch in length and as much as a week or ten days old were found in the trees at the end of the month. The period would, however, vary with the temperature—the greater the latter, the shorter the time passed as an egg.

The life-history of the larva.—The young larva on hatching out feeds in the soft sappy bark until its mouth parts are strong enough for it to attack harder substances, when it goes deeper down until it reaches the sap wood and commences boring out a winding gallery in this and the bast. The sap wood is grooved deeper and deeper as the grub grows older. The gallery eaten out is a broad irregular winding one and is packed with woody fibrous matter ejected by the grub after it has passed through the body; the gallery is very broad, as much as twice to two and-a-half times the breadth of the grub making it and the grub can turn round in the free space at the end in which it is lying. It is evidently a voracious feeder. Several galleries in the sap wood measured were as much as 9 to 16 inches in length excluding curves and four inches in breadth. The grub spends all the summer and autumn making this gallery. As soon as the winter sets in, it bores down into the wood, going down into the heart of the tree. The tunnel so made may be carried more or less horizontally into the tree or may go in at an angle; it is 3 to 5 inches in length, being much broader than the diameter of the grub constructing it and the latter can easily turn round in it (see Plate II A). The winter is spent in eating out this tunnel and the larva thereby escapes the cold which it would feel in severe seasons if it remained just beneath the bark in its gallery in the sap wood. This accounts for the at first inexplicable reason as to why the great cold experienced in Quetta during the past winter did not apparently in any way affect the number of beetles issuing from the trees this year. As spring approaches, the larva commences to carry this tunnel in the wood in a direction opposite to that in which it originally proceeded, and the portion of the tunnel now eaten out is the pupal chamber. This is some three inches in length and may be completed by about the end of May (see Plate II B). A number of full-grown larvæ at rest in this chamber and just about to pupate, were taken on the last day of this month. It was noted that these larvæ varied greatly in size, but this has no significance since the beetles themselves, as may be seen in the description of the insect, vary very greatly in size. This difference in size may vary to a certain extent with the degree of hardness of the wood of the tree in which the grub is living. It was noted, for instance, that the galleries in elm were of smaller dimensions than those usually found in the white poplar; these latter being invariably large. The size of the tunnel in the wood itself will also of course vary with that of the larva, but it is always from the commencement where it leaves the sap wood gallery down to the turn into the pupal chamber of considerable width, so broad that the larva can turn round in it, a number of grubs being found in this position at the end of May; its length, however, may be but little more than that of the grub itself.

It will be seen from the above that the larva takes from 12 to 14 months to reach its full growth after leaving the egg.

The pupation of the larva.—The larva pupates in the long axis of the tree and the pupal chamber appears to be invariably bored out in a contrary direction to that in which the larva was lying at the time it commenced this work. This chamber is always straight or but slightly curved and comparatively narrow when compared with the rest of the gallery in the wood above it. Having eaten out this chamber, it plugs the top with a mass of gnawed wood and lines the sides at times, if not always, with a papery lining of a brownish fibrous material. If it has not previously done so, it now backs out of the chamber into the broader tunnel above, turns round in this and proceeds backwards down into the chamber again and builds across the top of the latter a thick white wall of some calcareous substance, lining the sides of the chamber with the same material for a short way down. This wall effectually blocks up the chamber and prevents the entrance of enemies, who would be able to attack and feed upon the helpless insect whilst in its quiescent or pupal state. The time of pupation of the larva will vary by a week or so, depending upon the climatic conditions; but the end of the month of May and during June may be taken as the period during which the greater bulk of the grubs in the trees change into the chrysalis or pupa state. Larvæ hatching from eggs laid by beetles issuing as late in the year as July and August will pupate in these months of the succeeding year. Fully formed pupæ have been cut out of the pupal chamber in the trees in September, October. The fact that the fully formed beetles have been taken from the pupal chambers in February indicates that the time passed in the pupal stage is probably about 4 to 5 months.

The adult or beetle stage.—The insect commences to acquire its adult or beetle form in November or December (this period will vary by a week or two) and then passes several months resting in the pupal chamber, whilst its outer parts harden and solidify. When this has taken place, it bores its way out of the tree by gnawing a tunnel straight to the outside through the wood. This tunnel is eaten out by means of its stout black mandibles or biting jaws. The beetle does not, however, always leave the tree in this manner. It often, perhaps usually, simply breaks the calcareous partition made by the larva at the top of the pupal chamber and crawls up the broad larval tunnel in the wood and gnaws its way through the bark. In the majority of cases this would appear to be its usual method of leaving the white poplar trees. The beetles commence to appear from about the beginning of May and probably in April in years of mild winters and early warm springs. During the present year by far the greater bulk of the insects issued from the trees between the 6th and end of May. Considerable numbers were still to be found in the first part of June. The adult is much scarcer in July and August, though individuals are said to continue to issue during these months. The beetles pair soon after issuing, and the eggs are probably laid by the female within a week to 10 days afterwards. As has been already mentioned, the eggs are deposited by the females in the sappy bark of the tree, and to reach this, unless she can find any convenient wounds such as are made by lopping branches, abrasions to the trunk during heavy storms, etc., she bores down through the bark by means of her mandibles, forming small saucer-shaped depressions and, pushing her ovipositor down into these, deposits a cluster of eggs. She probably repeats this operation 5 or 6 times in different spots on a tree or trees. The egg-laying as also the safe hatching out of the eggs is undoubtedly greatly facilitated by (*a*) the presence of wounds on the trees, and (*b*) a warm dry spring, since a greater number of the young larvæ hatching from the 50 eggs laid will reach full development. The male beetle dies after pairing with the female and the latter after she has deposited all her eggs in the trees. Their dead bodies are to be found lying at the foot of the trees; they are, however, probably quickly eaten up by small rodents and other insectivorous mammals and also by birds, since, even towards the latter part of May when the beetles were issuing in thousands from the Quetta trees, dead insects were by no means numerous. From the above notes on the life-history it will be seen that the insect takes two years to pass through its life-history or life cycle; a fortnight in the egg; 5½ months feeding in the bast and sap wood beneath the bark; 6½ months in the wood in the interior of the tree; 5 months as a pupa; about the same time resting as a beetle in the pupal chamber; and 2 to 3 weeks in the beetle form outside the tree engaged in pairing and egg-laying. To facilitate a clear understanding of the life-history of the pest, it may be shown diagrammatically as follows :—

Diagrammatic table showing the life-history of the beetles which issued in Quetta in May and June 1905.

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1903 . .				††	††††	----	----	----	----	----	--□□	□□□□
1904 . .	□□□□	□□□□	□□□□	□□□□	□□□□	□□□●	●●●●	●●●●	●●●●	●●●●	●●●●	●●●●
1905 . .	○○○○	○○○○	○○○○	○○○○	††††	†						

Explanation—

†̣ = Egg stage.
— = larval or grub stage passed in the bast and outer sap wood.
□ = larval or grub stage passed in the interior of the wood of the tree.
● = Pupal stage.
○ = Fully formed beetle but with outer parts still soft, resting in pupal chamber.
† = Mature beetle.

When annoyed or frightened, the beetles, both male and female, produce a squeaking sound by rubbing the posterior inner dorsal edge of the prothorax over the anterior outer dorsal edge of the mesothorax, the thorax being moved up and down in the vertical plane to produce the sound.

In walking the beetle stands high upon its legs and holds its antennæ in front of the head, alternately tapping the ground with them after the fashion of ants. These antennæ are undoubtedly used as sensory organs of one kind or another. The insect sits low when at rest on the trunk of the trees. It usually takes refuge in the day time in old larval borings or its own exit holes which have weathered or rotted on the exterior of the trunk under the influence of the climate. In shady situations such as the Lytton Road, for instance, it may be found in the day time clinging to the bark of the trees. The grey silky colouring of the wing covers give it a wonderful resemblance to the bark of white poplar trees, and this undoubtedly serves as a protection to it, rendering it difficult to see on the trees at any distance. It is this great resemblance which would seem to give additional force to the argument that the insects' original food plant was this tree.

VI.—Method of attack, effect of attack on tree and how to detect attacked trees.

The two stages in the life of this pest during which actual damage is done to the tree are the beetle and grub ones. Wounds, such as those made by lopping branches, abrasions during storms, etc., are taken advantage of by the female beetles for laying their eggs in. Failing fresh wounds on the bark, the beetle has to bore through the trunk down to the sappy portion of the bark in order to deposit her eggs in a position to ensure there being an abundance of soft food for the young larvæ on hatching out. After feeding upon this for a period, the grubs, as they become older, work their way into the bast and sap wood of the tree, subsequently proceeding down into the wood to pupate. It is in the former stage of its life that the insect effects the greatest damage to the tree. An examination of many trees in Quetta will show that owing to the feeding of the grubs beneath the bark the larger part of the green inner bark (bast) is eaten away by the larvæ. Now if the grubs are at all numerous in the tree, these eaten out patches gradually join all round the stem and the result is that the tree is ringed, *i.e.*, the layer, up through the cells of which the sap proceeds to the crown of the tree, has been cut through all round and the tree dies. Even with the insect as plentiful as it is at present, the trees take some time to die, and this must be attributed to the fact that the beetles will lay their eggs on any part of the stem from the base up to the crown, in fact as high as there is a sufficient thickness to ensure there being a sufficiency of wood for the insect to bore into to form its pupal gallery. Owing to this fact, it takes longer for the patches eaten out by the larvæ to coalesce all round the stem in one band. At first sight this prolongation of the life of the tree might be considered an advantage, since it gives time for the growth of others to replace it. In reality, however, the position of affairs is very different. Trees so infested merely serve as a centre of infection for neighbouring unattacked trees, and the insects will go on laying in them until they (the trees) have arrived within a year of death. No beetle will then lay its eggs in them, since an abundance of fresh sappy bark and wood is essential for the grub's food. Cutting out dead trees, therefore, has absolutely no effect one way or the other in mitigating the damage done by the pest.

The detection of infested trees is comparatively simple·

(*a*) *Seriously affected nearly dead trees or dead trees.*—These are easily recognised. Large areas of the bark will have fallen away, disclosing the wood beneath deeply scored with the galleries of the larvæ, some of which may be still filled with the large masses of chewed wood and fibrous excreta. If this latter has already fallen from the galleries, the pulling off of another portion of the bark will disclose masses of it *in situ* in the galleries; from one portion of the gallery a hole will be seen proceeding down into the wood, and if this is traced downwards, the empty pupal chamber will be found.

(*b*) *Trees less badly attacked, but which will eventually die under the attacks.*—Holes and small rotting areas on the bark, often at the junction of branches with the main stem, are visible, and below these exudations of sap, either fresh and trickling or dred to the bark beneath the hole. These exudations are usually in large irregular masses tailing off below into thin trickles, the sap having dried on its way down the stem. If any of these holes with the fresh exudations trickling down them are cut into towards the end of May and commencement of June and examined carefully, they will be found to contain one or more little clusters of eggs placed on the edges of the bark and well down in the sappy inner portion of it; later on in June numerous young larvæ may be found here. If examined later in the summer, the careful paring away of the bark will disclose the grub in its half-formed gallery which grooves both the inner bark and sap wood. If holes on which the exudation has dried but is still fresh are cut into, they will show (provided they are not merely the old exit holes of the beetle, when they may or may not disclose other insects depending upon whether female beetles took advantage of them to lay eggs in) one of the following stages: if cut into in the autumn, the grub will be found nearly three-quarters or more grown, having nearly completed its sap wood gallery; later on in the winter the grub will be found to be boring its tunnel down into the wood; late in May it will be necessary to cut right down into the wood when the grub will be found in the interior in, or making, its pupal chamber.

If the exudation below the holes is dry and old looking, an examination of them will disclose in the autumn the pupæ in the pupal chamber in the interior of the wood, in the winter about January or February the fully-formed but still soft beetle in the same position and about the beginning of April the fully formed beetle commencing to or engaged in making its way through the layer of wood and bark or up the larval tunnel, or no insect at all, but merely this exit tunnel, if the galleries are more than two years old.

(*c*) *Trees but slightly attacked.*—These may show only one or two holes or patches of sap exudation, but according to the appearance of the latter and the time of the year it will be quite possible to form an accurate estimate of the stage arrived at by the insect in them.

VII.—Species of trees attacked.

The species of trees unaffected by the borer in Quetta are unfortunately few. The softer barked trees are all attacked.

The trees chiefly employed in planting the avenues on the roads in the station are the white (*safeda*), black (*kala safeda*), *reamer* and Euphrates poplars; the Kandahar, Kabul and weeping willows; the plane (*chinar*); ash; elm; mulberry; and apricot, whilst in the cantonments there are also some young horse chestnut and robinias.*

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* *Populus alba, P. nigra, P.* sp.; *P. Euphratica; Salix alba, S. æmophylla; S. babylonica; Platanus orientalis; Fraxinus* sp.; *Ulmus* sp.; *Morus alba; Prunus armeniaca; Æsculus indica; Robinia pseudo-acacia.*

Of these trees the black poplar, Kabul willow, ash, mulberry, apricots, horse chestnuts and robinias appear to be entirely unattacked by the borer. The chinar has only commenced to be infested during the last two years, no trees having yet been seriously damaged; the weeping willow is badly attacked, whilst the white and *reamer* poplars, the Kandahar willow and the elm, all of which trees have been planted in large numbers in the station, are being rapidly killed off by the pest. Further consideration of the elm is unnecessary, as but few trees now remain in the station, numbers of trees having been killed off and subsequently cut out.

VIII.—Results of the attack on the trees in the station and neighbouring villages.

(*a*) *To the trees in the station.*—The borer has obtained a firm hold over a seriously and annually increasing large number of trees and under its attacks a considerable proportion of these are either dead or dying. This condition is chiefly observable amongst the poplars (about 50 per cent. of the trees are species of this tree), Kabul willows, the few remaining elms, and to a lesser degree the weeping willow. No further damage is to be feared from the dead trees, but the badly attacked, in fact all the attacked trees in the station, are merely serving as centres for spreading the pest to trees at present unaffected. In this respect certain trees are much more dangerous than others, owing to the very large number of eggs, grubs and pupæ they contain.

(*b*) *To trees in neighbouring villages.*—Whatever may have been the origin of the borer as far as the station is concerned, its present abundance in the surrounding villages requires to be glanced at. In addition to scattered trees, the poplar is planted along the walls of the fruit gardens to act as a wind break and protect the fruit trees. A large proportion of these poplars and also the Kabul willows are badly infested with the insect and require to be cut out. In the village of Uhr this is being done in some gardens in order to prevent the wood from being entirely ruined. A 20 to 24-year old tree will fetch R5 if not rendered useless by the numerous galleries of the borer within. There can be little doubt that the villages are now suffering from the badly infested state of the trees in the station, and that the beetles have spread and are spreading from that centre into the surrounding country. Ordinarily, although the trees in a village might contain the insect, it would be in inappreciable numbers.

IX.—Areas in the Station affected by the borer.

The whole of the station is infested by the borer.

(*a*) *The Civil Station.*—As far as the planting and management of the trees are concerned, the civil station may be divided into two areas, the first of which is under the Superintendent of Arboriculture and outside municipal limits, the second under the Secretary to the Municipality.

(1) *Outside Municipal limits.*—The chief roads on which avenues occur are the Lytton, Gymkhana, Jail, White, Brewery, and Sandeman.

Lytton Road.—Planted with white and black poplars, chinar, Kandahar and Kabul willows, young elms, and ash. Of these the white poplar, Kabul willow, and elms are most seriously affected. The chinar trees, which chiefly occur in the station along this road, are also attacked, but only at present to a slight extent. These trees were first noticed as infested about three years ago.

Gymkhana Road.—Planted with white poplar and Kabul willows. These trees are for the most part seriously infested by the borer, many being either dead or in a dying condition.

Jail Road.—Planted with white poplar, *reamer* poplar and Kandahar willow. Both poplars are badly attacked, many being either dead or dying. The Kandahar willow is unaffected, but suffers from a fungus of the nature of a witches'-broom. This affects the branches resulting in the tree losing a large portion of its crown and apparently occasionally drying up entirely under the attack.

White Road.—Chiefly planted with ash, which is unattacked.

Brewery Road.—Planted with Kandahar and Kabul willow, Elæagnus (*E. hortensis*?) and ash. The Kabul willows are badly infested and the Elæagnus to a lesser extent.

Sandeman Road.—Planted at Lytton road end with apricot and at bazar end with poplars and willows. The apricots are unaffected, the other species seriously attacked.

The Residency and Private compounds.—The grounds of the Residency contain some fine old mulberry trees which existed before the station was formed. The place has been planted with white poplar, Kabul willow, chinar, and walnut. Of these the walnut is unaffected, the chinar to but a slight extent, whilst the poplars and willows are mostly full of the insect. The willows are but few in number, but the poplars are numerous. The private compounds and Club contain poplars, willows, ash, elms, fruit trees, etc. Of these it may be taken that a large proportion of the white and *reamer* poplars, the willows, and elms are more or less seriously infested by the borer.

(2) *Within Municipal limits.*—The municipal areas practically consist of the roads in the eastern portion of the civil station, and a number of the trees on them are seriously infested.

The trees on the municipal roads are chiefly Kabul willows (on the road near the Sandeman Hall and Museum) mostly badly attacked. Also ash (unattacked), white poplar (seriously infested), and Kandahar willow, the latter infested with the fungus and not with the borer.

(*b*) *Cantonment.*—The roads are under the Cantonment authorities and are planted with the same trees to a great extent as those in the civil lines. In addition they contain in parts horse chestnuts and robinias, both unattacked and doing exceedingly well.

Lytton Road.—The continuation of this road from the civil lines runs into and through cantonments over the Lytton Bridge. The trees on it are same as in the civil portion and are attacked to the same degree.

All the other roads planted with avenues are suffering from the borer, the white and *reamer* poplars and the Kabul willows being the trees most seriously affected.

The General's Grounds and private compounds.—The white poplars round the boundary of the grounds of the General's residence are very badly infested by the insect. There are a number of large trees planted just inside and outside of the boundary wall, and these are badly attacked. Some fine large mulberry are unattacked. Infested trees are present in most of the private compounds.

X.—Enemies of the borer.

A curious and remarkable feature which has come to light in connection with the large increase in the numbers of the borer observable this year is its apparent immunity from attacks of predaceous and parasitic foes to any serious extent. The closest observations and search have failed at present to show any predaceous or parasitic insects preying upon it, and this is the more remarkable since an undue increase in the numbers of individuals of any species is almost invariably, in the insect kingdom, followed by a similar increase in those of some insect enemy which preys upon it. The absence of such an aid to man renders the work of grappling with the pest all the more arduous and imperative.

One larva, nearly dead and with its body flaccid and thin, and a few beetles have been taken dead in the trees and they may have died under the influence of some parasitic fungus attack. If this be the case, however, the latter is evidently by no means common and owing to its great vitality the insect is usually apparently able to shake it off.

XI.—Past and Present Treatment.

But little attention would appear to have been paid to the operations of the borer until recently. Although the insect's presence has been recognised for several years past, owing to the absence of any available information upon or knowledge of its life-history, the grave danger arising from its presence in the trees of the station had not become apparent. A great and perhaps a natural reluctance was evinced to cutting out any trees, even seriously infested ones; no attempts were therefore made to stamp it out and the constant planting of fresh avenues but served to provide it with further areas of food-supplies and consequently stimulated its increase in numbers. Within the last year or so the gravity of the position has been forced upon the inhabitants owing to the ever-increasing numbers of dead and dying trees in the avenues and compounds and the all too obvious increase in the numbers of the pest. In the report called for last year, proposals were to be drawn up for endeavouring to get rid of the borer. The report was prepared by Mr. Porter, Superintendent of Arboriculture, and the measures suggested were:—

(1) To collect the beetles as they issued from the trees, a payment of four annas being made for every 100 caught. This operation has been carried out in all the divisions of the station, some 19,764 beetles (10,738 in the Superintendent's area, 3,435 in the municipality, and 5,591 in cantonments) having been caught and killed (*vide* Appendix).

(2) To cut out where possible the grubs from beneath the bark of the tree and to tar over the wounds thus made.

These measures have been put into force this year and are good as far as they go. They will not, however, prove sufficient to deal with the enormous numbers of the insect present in one stage or another in the trees. Catching the beetles is useful as a supplementary measure, but the weak part of it is that there is no certainty that by far the greater number of beetles so taken will not have already deposited the whole or a part of their eggs in the trees and therefore catching and killing them subsequently is of little use.

XII.—Recommendations for Future Treatment.

We have seen that the beetle lays about 50 eggs in 5 or more clusters and that these eggs are laid in the sappy living part of the bark of the trees. It is therefore important to bear in mind that all wounds on the trunk of trees during the period of egg-laying are so many facilities afforded to the female insect for her operations. Investigations would seem to show that the egg-clusters are not all laid in the same spot and therefore the beetle probably has to bore into the tree no less than five separate times to deposit the whole of her eggs. It will be obvious that this necessity greatly lessens the chance of all the 50 eggs developing. The beetle may itself be killed in one way or another before she has completed her work, the egg clusters may dry up owing to the hole she bores not being deep enough or all the larvæ developing from the egg clusters may not be in a position enabling them to find in their immediate neighbourhood a food-supply of sappy bark. In either of these eventualities the number of insects reaching maturity from the 50 eggs is greatly reduced. When, however, the trees have large wounds on them, such as are produced by lopping branches, the devastating effect of high winds and storms, etc., during the period of egg-laying (April to August, about) the beetle finds her work comparatively easy. All she has to do is to fly to these wounds and deposit the eggs on the edge of the cut or wounded bark at a spot at which the sap is oozing. There will be but small chance of the bark at these places drying before the eggs develop into larvæ, and a considerable proportion of these latter, under conditions so entirely favourable to themselves, will reach maturity. It therefore follows that such operations as careless pruning, lopping and hacking of the trees, cutting or boring into the bark, etc., during the egg-laying period is a direct benefit to the insect and it is in the lopping of the trees in Quetta that one of the causes for the present numbers of the beetle must be sought. The other must be attributed to the species of trees which have been made use of in planting up the station. These remarks are important as showing how the present position of affairs has arisen. The question now to be considered is how to get rid of the eggs, larvæ and pupæ of the pest now present in the trees and of the swarms of the beetle when they appear at the egg-laying season. The following are my recommendations :—

(1) *All seriously infested trees must be felled, cut up, and burnt if the rest of the trees in the station are to be preserved from attack.* Several objections are likely to be raised to this procedure:—

- (*a*) The beauty of the station will be impaired.
- (*b*) Roads at present comparatively shaded, although almost every tree is seriously infested with the borer, will be exposed to the full force of the sun's rays with the removal of the trees.
- (*c*) The difficulty in procuring labour to carry out the work.
- (*d*) The objections of the owners of private compounds to cutting their trees.

These objections may be met as follows :—

(*a*) and (*b*) The failure to remove the badly infested trees now will not prevent their future removal by death at an early period and during the interval thousands of beetles will hatch out of them to lay eggs in at present unattacked or but slightly-attacked trees; the trees are thus serving as so many centres for the further spread of the pest.

(*c*) This difficulty of procuring labour has been mooted on several occasions. It may be suggested that it might be met by enlisting the co-operation of the Military authorities. It will be apparent to all who have studied the question that the work to be done is of considerable magnitude and will require a very considerable amount of care and supervision to be exercised in its performance.

(*d*) If the work is undertaken at all, it must be in a thoroughly efficient manner, so as to endeavour to stamp out the beetle once and for all. To this end the station must be considered as, and worked over as, a whole.

(2) *The trees should be felled in the latter part of October and on through November.*—This period is fixed, since it will be certain that by then all the beetles of this year will have issued from the trees and deposited their eggs within them.

(3) *All felled trees to be cut up and the material burnt.—This latter is essential.* It might be thought that once the tree has been felled and cut up all further danger from it is at an end and that consequently the wood could be sold for firewood, etc. This is not so. We

have seen from the life-history that the grub bores down into the wood to pupate and that pupæ are found in the trees in September and October. It follows that all the felled trees will contain numbers of pupæ resting in pupal chambers in the tree. Now felling the tree, although it will lead to the death of all the younger larvæ (the grubs of the year) which at the time will either be in the bark and sap wood or just commencing to bore down into the wood, will not in any way affect the pupæ and consequently all these will issue as beetles in the following year in April, May and will escape to lay eggs in the standing trees. No matter in what form the wood of the felled trees may be in, *e.g.*, beams, posts, logs, firewood billets, etc., provided they exist as such in the beetle season of the succeeding year, the insects will bore their way out of them. All wood which can be used as firewood and *burnt for certain* by the end of February (1906) could be so made use of, but no risk should be run of any of this wood not being so used up within the prescribed time, or the value of the felling will be lost. It would be by far the safest plan to turn the whole of the felled trees if possible into charcoal, even though the quality of the latter would be poor, soft wood trees not being good for this purpose.

(4) *Selection of trees to be felled.*—This is a point of the very first importance. Whereas on the one side the failure to cut heavy enough, *i.e.*, to remove all the seriously infested trees, will minimise to a very large extent the good results to be attained, overcutting will unnecessarily spoil the beauty of the station without giving any adequate return. Every tree removed will require the most careful selection and examination before it is marked for felling. Since the work has only to be done once, too much care and thought and time cannot be given to the subject. There are trees—a large number of trees—in the station which even the inexperienced eye can see require prompt removal. Others there are, however, equally dangerous and in some cases even more so, since the very bad ones have already supported so many larvæ that their power for harm has been greatly reduced and is rapidly reaching a negative quantity; the trees to which I allude, though showing but little exterior evidence of infestation and consequent damage, are in reality the most important for removal, since they are the ones which are now taking the place of the old heavily-scarred nearly-dead trees and are serving as *the* centres for the further distribution of the pest. Considerable care and experience will be required in picking out these

trees for removal, and in the manner in which this operation is done will lie the whole success of the fellings.

(5) *Provision of Trap trees.*—Trap trees are trees which it is intended to purposely leave as lures for the insects to lay in, the intention being that they should be removed, cut up and burnt, as soon as they are full of larvæ and pupæ. The selection of such trees will require considerable care. On the one hand, it will be useless choosing as trap trees those which are already so badly attacked that they are within a measurable distance of death. Conversely it will likewise be of little use selecting healthy trees on the off chance that they may be attacked by the beetles. Further, we must remember that the object is to preserve all the at present unattacked trees in the station. In a forest attacked in this way by beetles the plan usually followed is to select certain trees and girdle them. In their slowly dying condition they will be certain to be chosen by the pest it is wished to trap. I do not wish to make use of girdling in Quetta, since the number of trees requiring urgent removal is already so great that it should be a first object to preserve every tree there is the slightest chance of saving to the station and not to add, if possible, to the number of those requiring removal. It is for this reason that the prescribed fellings will require to be undertaken with the greatest possible nicety and discrimination. These trap trees would be left for the beetles issuing next year to lay in and be cut out and burnt in October (1906).

(6) *Collection of the beetles.*—The operation of collecting the beetles should be subsequently organised the year following the felling (1906). If possible, a gang of coolies should be entertained to work through the station as a whole. By the number of beetles thus captured it will be possible for an estimate to be made—

(*a*) Of the value of the previous year's felling.

(*b*) Whether it will be necessary to make a supplementary felling in October-November 1906.

(7) *Lopping.*—Wherever a branch is lopped or a tree is seen to bear a bad wound on the bark of the trunk or near the base of the larger branches during the months of egg-laying (April to August), the wound should be covered with a good coating of tar. A standing order to the effect that this operation should be done in every case at all seasons of the year would be advisable, since the spores of fungi are liable to get into such places and set up decay.

(8) *Time to lop.*—No lopping work should be undertaken between April and October.

It will not be necessary at present to consider methods for combating the attacks of individual larvæ during the first year of their life, at which period they are to be found in the sap wood and bark. At present their operations are upon such an extensive scale that no attack upon individual grubs is of any use. It will be soon enough to consider their treatment when we have seen the result of the October-November (1905) felling and the April-June (1906) catch of beetles.

XIII.—Recommendations for future Planting.

In connection with the recommendations for combating the attacks of the borer pest a few remarks may be made upon the species of tree to be used in the future planting work in the station. With adequate supervision by trained men it should not be possible for the trees in the station to ever again reach their present deplorable condition, and I would not therefore advocate the exclusion of any species of tree with the exception of the reamer poplar and the Kabul willow. I would recommend that the white poplar should never in the future be planted in pure avenues or in mixed ones still containing any remaining rhema poplars or Kabul willows. The planting of the avenues of pure poplars or poplars and willows only has undoubtedly been a great help to the beetle. The Kabul willow should be condemned altogether, but the planting here and there in an avenue of a white poplar both adds to its beauty and would in no way lead to any undue increase of the borer once it has been reduced to insignificant numbers. The walnut and horse chestnut might be made more extensive use of in the future in avenues and the same applies to the chinar which ordinarily would, I think, be quite safe from the attacks of the pest, whose natural food is soft barked trees. The elm should be condemned, but the ash and robinia be planted on a large scale. General Smith-Dorrien pointed me out a number of young robinia in cantonments which were thriving wonderfully well and whose size for their age was remarkable. Mixture in avenues is to be recommended and might be resorted to on a larger scale than has been carried out to date. As a general rule, no new species of soft-barked trees should be introduced and planted in any numbers in the station, since it has become apparent that all such are attacked by the borer. It would be advisable to issue an order to this effect and make it known throughout the station.

It would be advisable that a simple set of rules should be drafted laying down the species which it was permissible to plant throughout the station as a whole, including private compounds. Such rules would then serve for the guidance of public officials and private inhabitants alike.

XIV.—Points in the life-history requiring further observations.

The life-history of the pest as given in this note requires corroboration. It may be taken as certain that the dates of issuing of the beetle, egg-laying, and the periods at which the larva bores down into the wood, after completing its work in the bark and sap wood, will vary slightly with the climatic conditions. A cold or wet winter, spring or summer will naturally delay the appearance and the various changes in the metamorphosis of the insect and consequently the laying of the eggs, whilst an early winter will cause the larvæ to bore into the wood at an earlier date.

With the exceptions of these minor points (points which, however, require to be borne in mind when carrying out operations to get rid of the insect), the life-history of the Quetta borer may be now said to be fairly well known.

XV.—Summary.

To shortly summarise the above note :—

The station of Quetta is at present infested by a boring beetle whose larva feeds first in the bast and sap wood of the tree and subsequently in the inner wood. Trees infested with a large number of the grubs finally lose the greater part of their bast layer (the living layer of the tree) and as a result die off.

Of late years the insect has increased in such numbers that it is at present destroying a large proportion of the trees in the station and thereby threatens the almost total extinction of the avenues in the near future.

The note deals with a description of all the stages of egg, grub, pupa and adult of this pest and details its life-history which is now known in almost its entirety. It has thus become possible to make recommendations for combating its attack. Such recommendations involve the cutting out of all seriously infested trees in October, November and burning the whole of the cut-out wood ; and the collection of the beetles by gangs of coolies the following April-June in order to ascertain the results of the previous year's fellings. The fellings must be carried out throughout the station as a whole.

A few remarks are made upon the origin of the insect, its presence in neighbouring villages, the absence of predaceous and parasitic foes attacking it and the best species of tree to plant in the future.

APPENDIX.

Locality.	May.																										June.															Total No. beetles caught in May.	Total No. beetles caught in June.	Total No. beetles captured.
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
Agency	597	873	1242	1267	1085	699	1140	1330	896	84	40						125	200	70	54	155	100	110	75	90	115	35	71	4			70	26	26	27	25	22	11	9	3	2	10407	331	10738
Municipality . .							233	1700										1502																								3435	...	3435
Cantonments . .				346	740	955	1303	1055	74	53	60															5																*4591	...	4591
																																										*1000	...	1000
																																					Total .					19433	331	19764†

* *N.B.*—In addition to the above, a 1,000 beetles were caught in the grounds of the General Officer Commanding, Quetta Division, and many more in the compounds of private bungalows.

† No record was kept as to the proportion of females to males amongst the captured insects.

G. I. C. P. O.—No. 1294 R. & A.—22-9-1905—1,709.—P. M. M.

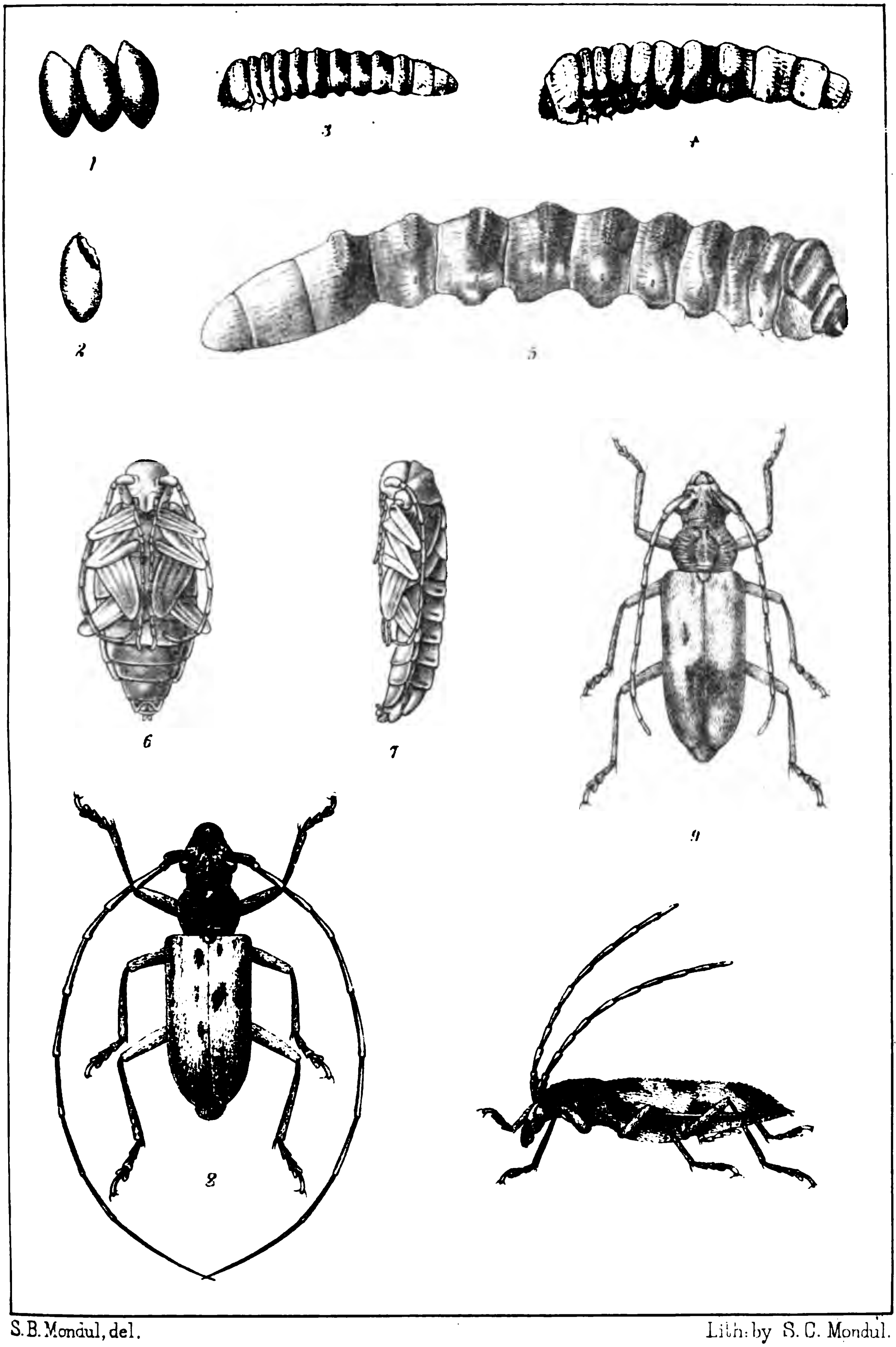
EXPLANATION OF PLATES.

PLATE I.

1. Cluster of 3 eggs (magnified 4 times).
2. Single egg from which the young grub has hatched out (magnified 4 times).
3. Young grub (magnified 4 times).
4. Grub about ⅓rd grown.
5. Full grown grub just before pupating.
6. View of under surface of pupa.
7. Side view of pupa.
8. Male beetle.
9. Dorsal and side view of the female beetle.

(Figures 5-9 natural size.)

Stebbing-A note upon the Quetta Borer. Plate I.



S.B. Mondul, del. Lith: by S. C. Mondul.

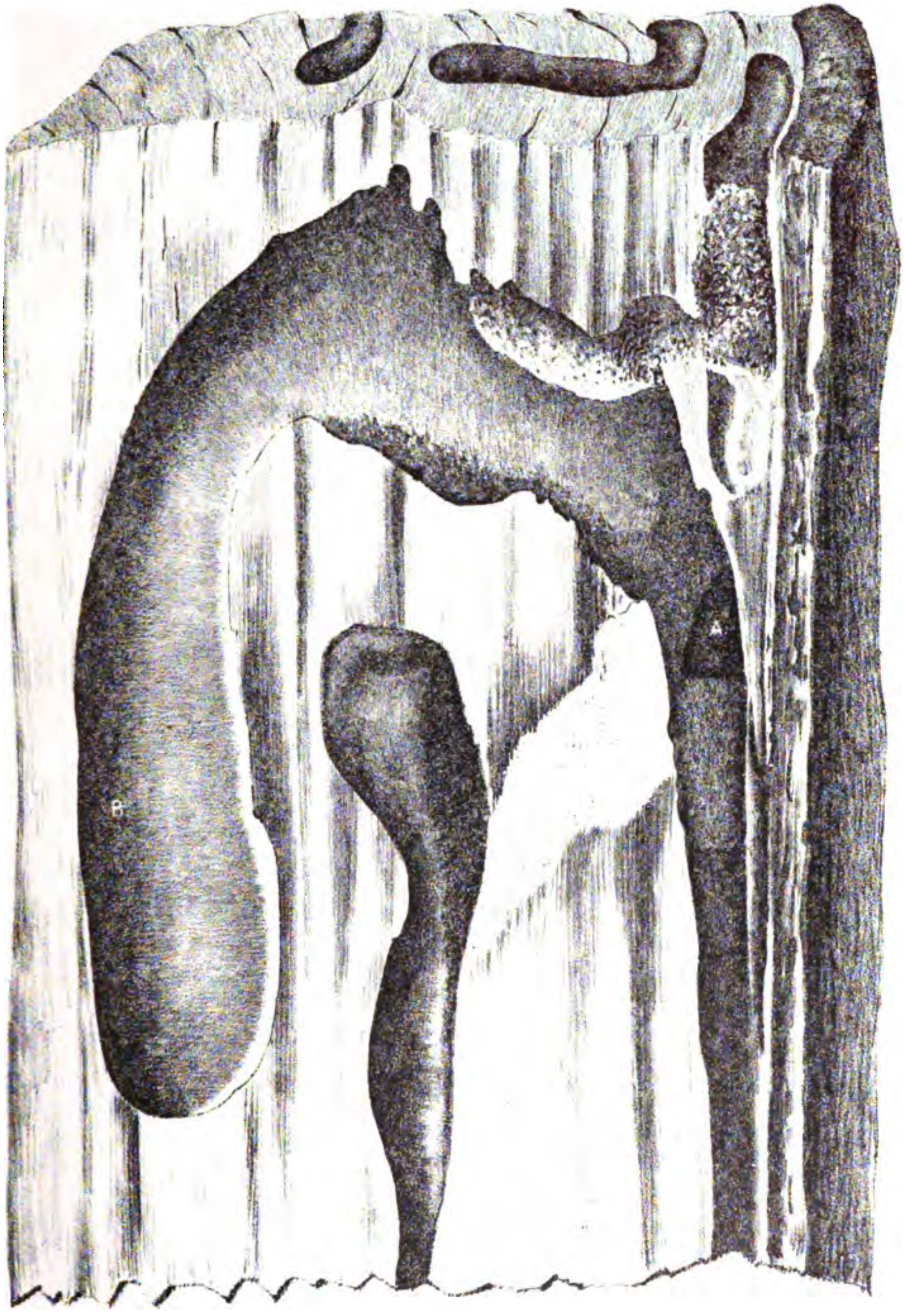
The Quetta Borer.

PLATE II.

Portion of the trunk of a white Poplar showing galleries made by the Quetta Borer.

A.—The gallery in wood made by the grub.

B.—The pupal chamber.



S. B. Mondul, del. Lith: by S. C. Mondul.

Portion of the trunk of a White Poplar
showing galleries made by Quetta Borer.

A NOTE

ON

THE CHILGOZA (PINUS GERARDIANA) BARK-BORING BEETLES OF ZHOB, BALUCHISTAN.

BY

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General Remarks.

SOME two years ago the Political Agent, Zhob, Lieutenant-Colonel Chevenix-Trench, reported that the trees in a Chilgoza forest on the Shinghur range of hills in the Sherani country appeared to be dying out under the attacks of an insect. This fact seems to have been first recorded by Major McDonald when Political Officer of Zhob in 1898, but no practical steps had been taken in the matter until Colonel Trench made his report to the Inspector General of Forests in 1903. In this latter the Political Agent asked whether it would be possible to take any steps to prevent the forest being destroyed. The correspondence on the subject was forwarded to me at the Indian Museum in Calcutta, of which I at the time held officiating charge. Unfortunately it was not found possible to procure any of the insects the following year but a section of a badly infested tree was despatched to the Inspector General of Forests. An examination of this log showed that the trees were infested by a species or species of *Scolytidae* or bark-boring beetles and to such an extent that the tree in question had evidently been killed by the insects. The outside bark looked exactly as if the log had been stood up on end and fired into all round from a distance with No. 8 shot, whilst, on removing it, the whole of the bast layer was seen to be a network of longitudinal galleries made by the beetles and of transverse ones made by their larvæ. Practically the whole of the bast layer had been removed by the insects, with the result that the tree had died. So serious was this attack considered to be that on return to India from furlough arrangements were made to visit Zhob the following summer, this note being the result of investigations carried out in the Shinghur Forest in June. That the observations made have resulted in successfully working out the life history of two generations in the year of the pests must be attributed to the exceptional facilities and arrangements made for me by Colonel Trench, who himself accompanied me on several of my visits in the forests and afforded explanations on the many points involved, a knowledge of which was an undoubted aid in solving the problem.

II.—Situation, Aspect, and Appearance of Shinghur Forest.

Shinghur Forest lies 30 miles to the west of Fort Sandeman and is situated roughly between 7,800 and 9,300 feet elevation. A few scattered trees are found below the lower elevation, the upper one being the height of the Survey bench mark on old Shinghur hill. The range consists of a saddle running north and south connecting a number of spurs, jutting out from its eastern face, and covered more or less with trees on their upper portions; the western side is mostly of a precipitous nature the whole length of the range and in places drops sheer down to the Sherani country below; it is covered with trees wherever the configuration permits of their growth. To the south of the Shinghur bungalow the forest continues for a mile and then thins out and disappears. To the north the saddle rises and ends in the old Shinghur hill about a couple of miles or so from the bungalow. Skirting round the base of the small hill which terminates the saddle the ground rises through forest to a small open maidan about ¾ by ¼ mile; from here it drops away to the north for approximately two or more miles, consisting of what are really a succession of small spurs running east and west. It is on this area that the finest part of the Shinghur Forest is to be found. The average width of the forest may be taken as a mile, the trees in places thinning out to much less, whilst in others, and notably in the better portions, the width is much more. The spur jutting out from old Shinghur, which has the small maidan on its western edge, is by far the largest being considerably over two miles in length; its southern face is precipitous whilst its northern drops gently and is covered with the fine part of the forest mentioned above. The southern portion of the forest is very open, the trees being in places greatly scattered, stunted, and having the gnarled and spreading appearance of old oaks at Home. It may be noted that this spreading habit is not the defect it would be in other forests since the trees are principally of value for their seeds and the larger the crown area the greater the production of cones. Nevertheless this portion of the forest is too open. Along the saddle connecting the southern and northern areas the trees are very scanty and of small size. In the northern portion, the growth is far denser, the trees of greater height, and the forest undoubtedly of very considerable value. It is proposed to describe this forest in a separate note, but it may not be out of place to mention here that the principal enemies the trees have had to contend with have been goats and sheep and bark-boring beetles. Conspicuous throughout the area are the dead trees killed by these latter; the open character of the southern portion of the forest is undoubtedly attributable in part to the beetles.

III.—The Dead Trees in the Shinghur Forest.

Throughout the forest but perhaps commoner in the southern than in the northern area stand considerable numbers of dead trees, their white trunks and larger branches, from which in many cases the bark has fallen, and their needleless crowns rendering them very conspicuous. To any one inspecting the Shinghur Forest for the first time this prevalence of dead trees would be a point to at once strike the eye. A closer examination of these trees will disclose one of two facts and this will be found to be the case throughout the forest. If the bark is still on it will look as if it had been fired into with No. 8 shot and this appearance does not apply to the trunk alone but to the large spreading branches and those in the upper portion of the crown of the tree as well. If owing to the length of time the tree has been dead, the bark (which in this tree is a very thin one) has flaked off the sap wood beneath will be seen to be covered with an intricate network of galleries and small holes. The larger and longer galleries are longitudinal ones, the shorter and finer transverse ones which end in little depressions or pits in the wood. The galleries and pits are the work of bark-boring beetles and their grubs and the death of the tree has resulted from their attacks. As we shall see later the galleries in the smaller branches have a stellate appearance and are made by a different species of beetle to the ones boring in the stem and larger branches. What is true for one dead tree bearing these tell-tale marks on the trunk and branches is true for every similar tree throughout this forest.

IV.—Infested living and dying trees. Signs of Attack.

Leaving the dead trees if we now commence to inspect the sickly and dying ones we shall find that a number of them will be seen to have lost great strips of bark from their trunks or larger branches; the sap wood so exposed is usually covered with the old galleries of former generations of the bark-boring beetles. An inspection of the living bark on the stem and branches of such trees may show small holes encircled with rings of resin and if the bark is removed at this point beetles or grubs will be found beneath it. This means that the tree is being again attacked by the beetles. If the holes are numerous and spread all over the surface of the remaining bark the tree will die and the foliage will probably have already turned yellow – an unfailing sign of death in a pine tree. At Shinghur it will be noticed that exposed trees are usually attacked on their northern sides first, the side most protected from the sun. In the shade of the forest however the beetle commences on any side.

It is a comparatively simple matter to find attacked trees. Owing to its thin bark and the copious amounts of turpentine contained in it the slightest prick or cut in the tree results in an outflow of turpentine. It follows that when a beetle bores into the bark to reach the bast layer and sap wood an outflow of turpentine results; this forms a trickle below the hole of entrance of the beetle whilst at the same time a small circular rim of resin is formed on the bark round the hole. The trickle below is often congealed into an elongated pear-shaped mass. When the beetles have attacked the tree in numbers the whole trunk or one side of the trunk may be seen to be comparatively thickly covered with these holes and pear-shaped drops of resin and turpentine which, with the sun's rays glinting on and through them, can be seen glistening at a considerable distance. If this is the first attack on the tree and only one side of the stem is infested the tree will not die, although it is possible and probable that it may lose some of the branches on the side attacked. If the whole trunk or all the remaining portion of it containing living bark is infested a careful watch will soon show the foliage to be turning yellow. By the time the eggs being laid by attacking beetles have themselves produced a generation of beetles the needles will be dropping and the tree will be practically dead.

V.—Origin of the Infestation.

An endeavour has been made to ascertain the origin of this bark-boring beetle infestation in Shinghur. An inspection of the area and of the number of infested and dead trees taken in conjunction with the comparatively small numbers of young and middle sized trees present has made it apparent that whilst in all probability the insects have been in the trees in certain numbers for a very long time yet nevertheless the great damage done, and being done, to the forest has originated within comparatively recent years. The number of dead trees still standing in the forest would in themselves prove this to be the case but better evidence of the truth of the supposition is to be found in an examination of the insect galleries in the sap wood. In the majority of cases the galleries can be traced with ease and the record of the beetles' presence can be placed within the last few years since, under the action of climatic influences, the comparatively shallow galleries made by the beetle and its larvæ would soon 'weather,' become indistinct, and finally disappear from the outer sap wood altogether.

Several of the Maliks on being questioned about the dead trees said that some had always been present in the forest but taken altogether their evidence on this head is not of much value. Their answer that 'the trees died by the will of God and who could tell why' was of interest as it showed that they had no previous knowledge of the real facts of the case. We were able to give these men a practical illustration of the real cause of the death of the trees, which demonstration Colonel Trench was of opinion would be of considerable value to the members of the surrounding tribe as a whole, among whom it has been made known.

VI.—The bark-boring Insects.

Observations have shown that there are at least 3 species of bark-boring beetles attacking the Chilgoza trees in the Shinghur Forest. Of these two only are found in the trunk although they will also attack the branches whilst the third confines itself solely to the smaller branches and therefore is of small importance as far as the big trees are concerned, since they do not die under its attack. This insect has however to be carefully considered as it may infest young saplings.

The first two of these beetles are apparently new to science. The larger of the pair, a species of *Polygraphus* is the most serious pest the trees have to fear and the chief cause of their death whilst the other is a species of *Phleosinus* and is to be found in company with the *Polygraphus* in both trunk and branches. It comes in however later than the *Polygraphus*, and therefore in all probability does much less harm.

The third beetle,* alluded to above as confining itself to the smaller branches, is identical with the insect taken by me in Chilgoza trees in the N. W. Himalaya near Kilba in the Bashahr State and also commonly in the blue pine and spruce in Jaunsar and Tehri Garhwal; its name is *Pityogenes coniferae*, Steb.†

DESCRIPTIONS.

The following are descriptions of the various stages of the metamorphosis or growth of these insects:—

Polygraphus Trenchi, n. sp.

Egg.—The egg is small, white, round and translucent.

Larva or grub.—A small curved white maggot with a yellow head and no legs. It is shown in plate I, fig. 1.

Beetle.— ♀ Oblong cylindrical, black, moderately shining; two brilliant prominent reddish golden brushes of hair on the front of the head; base of thorax with at times a reddish tinge; the elytra (wing covers) black or very dark brown with a yellowish tinge their bases often black, the black portion often triangular in shape; the upper surface is more or less covered with small stiff white hairs, densest laterally. The head is small and black and is partially covered in front by two curved brushes of long stiff reddish-golden hairs (fig. 1*c*.) which take off from the anterior edge of head and occupy all the area between the inner upper edges of the eyes except a narrow channel medianly. These long brushes of hair curve towards one another medianly (the tufts on the two sides remaining apart) to about halfway down the front of the head and then continue down it in two thin strands; a few separate hairs start from the inner surface of the eye and converge to meet the strands near their upper ends. The position and configuration of these brushes of hair serve easily to distinguish the insect. There is a brush of yellow hairs at the mouth and the antennae are yellow and terminate in a solid club. The thorax is ⅓rd as long as broad, and is sharply constricted at about the basal fourth the outer angles being constricted and rounded; a median shining longitudinal line down central portion; the surface is finely pitted, but the pits are not placed closely together; the lateral margins set with a fringe of rough hairs. The elytra are finely striate, the intervals between the longitudinal striations filled with fine close granulations which become larger and wider apart in apical fourth. Under surface black moderately shining and set with small rough projections and with sparse stiff yellow hairs. Legs yellow dotted with yellow hair; tibiae (shanks) of front legs brownish black. Long. 3·12 to 3·4 millim.

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* There is a fourth, a beetle slightly larger than the *Polygraphus* and probably belonging to the genus Hylurgus or a colsely allied one. I only took three specimens of this insect in a gallery they were eating out in a small branch. As it is apparently rare I have not deemed necessary to treat of it here.

† Departmental Notes on Insects that affect Forestry, No. 2, page 212, plate XIII, fig. 4, *a* to *f*.

♂ Differs from female in its smaller size in the absence of the remarkable reddish-golden brushes of hair on the front of the head, their place being taken by a few sparse yellow hairs, and in the presence of two small tubercles on the head, placed transversely. The hairs on the upper surface are also denser. Figs. 1*b* and 1*e* show dorsal and side views of the female and male beetles. Long. 2·6 to 2·8 millim.

I have pleasure in naming this Polygraphus after my friend, Lieutenant-Colonel G. Chevenix-Trench.

Phleosinus ? sp.

Egg.—Blunt, elliptical in shape, white and translucent (see fig. 2).

Beetle.— ♀ Oblong cylindrical, black, the thorax and elytra with at times a reddish tinge.

Head black finely and closely pitted, sparsely covered with a few fine short white hairs. Eyes reniform with the anterior margins straight. Antennae yellow, funiculus 4-jointed and club with four articulations. Thorax constricted in front at upper third, finely and densely pitted, with a sparse white pubescence over it. Elytra striate—punctate with a row of deep punctures down the striae, the intervals being convex with fine punctures; in apical fourth the large punctures disappear and the striae are very faint; the apex is set with spikey protuberances or teeth which extend laterally up the sides; the elytra are covered with a scattered white pubescence denser at sides and in apical portion. Under surface black, with long stiff sparse hairs; finely pitted. Abdominal segments narrow. Legs reddish brown, covered with sparse yellow hairs; tarsi yellow; tibiae armed with four teeth on outer edge and terminating in a longer tooth on inner upper edge. Long. 1·9 millim. ♂ Smaller than ♀, elytra reddish, the white pubescence being absent. Apex of elytra with fewer teeth. Long. 1·5 millim. Figs. 2*a* and 2*d* show dorsal and side views of the female and male beetles.

Pityogenes coniferæ, Steb.

The larva, pupa and adult insect of this beetle have been already described in *Departmental Notes on Insects that affect Forestry*, No. 2, page 244. Better enlarged drawings of the female and male beetles are shown here in plate I, figs. 3 and 3*c*.

VII.—Life Histories and Methods of Attack in the Trees.

It has already been shown that all the three insects attacking the tree are bark-borers, *i.e.*, insects which tunnel in the bast layer and sap wood of the tree, as distinguished from those insects which tunnel down into the wood, and up to a certain point there is a certain similarity in their times of appearance, methods of operation and consequently, in their life histories. Each of the three species commences to bore through the bark of the tree to lay its eggs in the bast layer in the early spring. These eggs hatch out in a very short time and the resulting grubs feed in the bast layer and sap wood for some few weeks or so until they reach their full size. They then turn into the pupal or chrysalis stage, changing after a fortnight or three weeks into the beetle; the latter on becoming mature bores its way through the bark and escapes from the tree. These beetles tunnel into fresh trees, pair, and the females lay the eggs of what is the second generation of the year. It is probable that both the *Polygraphus* and *Cryphalus* beetles pass through at least three and in warm autumns four generations in the year, and it is this great prolificness which renders them such dangerous pests. It has been already shown* that the *Pityogenes* passes through three or four generations in the year.

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* Departmental Note No. 2, p. 243.

We will now deal with each of the life histories in detail and describe how the insects actually attack the tree.

The *Polygraphus* beetle.

This beetle is the chief aggressor and is mainly responsible for the damage done to the trees at Shinghur. Out of the large number of infested chilgozas examined, four may be taken as representative of the various stages in its metamorphosis in which the *Polygraphus* was found in the latter half of June.

(1) Mature larvæ, pupæ and fully formed but immature, light yellow beetles with their outer parts still quite soft. Also one or two fully mature beetles and a few dead ones at the top of the egg galleries in the tree.

(2) Fully mature males and females boring into a standing green tree or grooving out pairing chambers or egg galleries in the bast and sap wood. Eggs laid in the lower part of the egg gallery but no grubs yet developed.

(3) Fully grown larvæ, pupæ, immature and fully mature beetles. These latter were issuing at the time the tree was inspected and were attacking a perfectly green tree in the neighbourhood.

(4) Fully mature male and female beetles, eggs and young larvæ, the tunnels of these latter giving off at the lower portion of the egg gallery being already as much as ½ inch long.

From the above material it is a comparatively simple matter to detail the life history of this pest from the time that it began its operations after the period of winter hibernation. The insect most probably passes the winter hibernating as a beetle or grub; in the case of such a thin-barked tree as the chilgoza it would be certainly killed off in the pupal stage by the frost, and the same may be true of the eggs. If it hibernates as a beetle it issues from the bark as soon as the warmth of spring makes itself felt and bores into fresh trees to lay the eggs of what will be the first generation of the year. Should the insect pass the winter in the grub stage these latter will turn into pupæ with the first warmth and the latter shortly issue as beetles. In the latter event it will be seen that the individuals who passed the winter in the mature state will have a start over those who were in the larval one and this accounts for the apparent overlapping of generations which may be noticed in the case of this and other bark-boring beetles. By overlapping of generations

I mean that in one and the same tree may be found egg galleries with the off-shoot larval galleries well advanced and therefore a week or two old whilst others are only just commenced by the mother beetles, they being a week or two behind the first insects to enter the tree.

In the first tree mentioned above mature larvæ, pupæ and immature beetles were found. These had all developed from eggs laid sometime early in May of the present year. The attack commences by a male beetle boring into the tree through the bark until it reaches the sap wood. In this it eats out a depression and this depression is termed the pairing chamber. It is here joined by a female beetle who enters by the same hole. After pairing with the male the female commences to eat out a longitudinal gallery which is always more or less parallel to the long axis of the tree (*i.e.*, to the direction of the length of the trunk or branch). This gallery is slightly broader than the width of the beetle. On either side of it she eats out little recesses and places one egg in each. These recesses occur on both sides of the gallery but are usually more numerous on the one side than on the other and are closer and more evenly distributed in the lower portion than towards the apex. See fig. 6 in plate II: *a*, pairing chamber, *b* egg gallery, *c* recess in which egg is placed. In fact as the egg gallery becomes longer the beetle's egg-laying powers appear to become weaker and more erratic. In the roof of this gallery, *i.e.*, in the bark, she bores small circular holes which pierce through the bark but do not reach quite to the outside, a mere plate of cortical epidermis of paper-like thickness being left to cover the hole from the outside air (6*d*). Two or more holes of this nature are made and they serve to admit air into the egg and future larval galleries. These holes are not carried right through to the outside in order to prevent predaceous and parasitic enemies from gaining access to the inside and destroying the grubs, pupæ or beetles within. These air holes appear to be bored in the most erratic manner. At times the egg gallery will contain three or more right at its commencement and their number and position doubtless depends to a great extent on the healthiness of the tree and the amount of turpentine it is capable of exuding at the spots attacked. If this is in such quantities that the entrance hole of the male and female beetles becomes blocked the females doubtless have to add considerably to the number of the air holes in their galleries. This may also in part be responsible for the number of female beetles who enter and pair with a male. This number is evidently very variable, at any rate in the case of the spring and early summer generations. There are always two but there may be as many as four. The second female beetle entering by the entrance hole, after pairing with the male, carries her egg gallery in the opposite direction to that of the first. If the latter has gone up the tree she will go down and *vice versâ*. These egg galleries, at any rate in their lower halves, are always packed with the wood dust eaten out by the beetle as she carries the tunnel onward and this probably prevents a second female from commencing her gallery in the same spot. If a third beetle pairs with the male she carries her gallery either up or down the trunk parallel to, but not in connection with, that of the one which has previously taken this direction. If there are four females two egg galleries will be found proceeding up the tree and two down, each taking off from the pairing chamber. I have never found more than four females with one male. At times as many as three beetles will be found in the pairing chamber, perhaps a short egg gallery having been started at one or both ends. In this case it is possible that the female beetles help the male to enlarge the pairing chamber. The galleries vary in length from 1¾ inches to 2¾ inches, the number of eggs laid in each being from 14 to 18. Probably about a week to 10 days is spent in making the egg gallery and the lower eggs hatch out into grubs before the beetle has finished boring the gallery and egg-laying (6*e*). Only a day or two is spent in the egg stage. The grubs on hatching tunnel away from the egg gallery in a direction which is more or less at right angles to it in the case of the first laid, and therefore the lowest, eggs, the direction, however, trending upwards (or downwards when the egg gallery is carried downwards) in the case of the eggs laid higher up the gallery. In this manner a pattern which has a constant definite plan is made. The larval galleries are short not being more than 1¼ to 1½ inches in length and they groove both bark and sap wood. When full grown the larva eats out in the sap wood an oval-shaped depression and changes into a pupa within this. Plate III, fig. 1 shows a piece bark completely covered with the pairing chambers, *a*, egg galleries, *b*, larval galleries, *e*, and pupating chamber, *f*. The pupa turns gradually into the immature beetle and the latter remains for a time in the chamber whilst its outer parts are slowly hardening and it is becoming darker in colour. When fully mature the beetle bores straight out of the bark by a tunnel eaten out horizontally from the spot where it is lying. In the case of the spring generation, when the weather is still comparatively cold, as much as five weeks are probably spent in the larval stage and a fortnight in the pupal and immature beetle stages, the generation taking about two months to complete from egg to perfect insect. It will be understood from the above that numbers of the beetles will mature and leave the tree together and this is what actually happens and explains the state of affairs seen on the second and fourth trees alluded to above. In the first and third the insects maturing were those from the first set of eggs laid in the spring of this year. In the second and fourth we find beetles all more or less in the same stage, *i.e.*, the egg-laying one (especially in the case of the second tree), the reason being explained by the fact that they had left the tree in which they had been bred in a swarm and flown together to the one in which they were found.

The above explains the life history of this insect as far as it had been carried up to June 21st of the present year. From a knowledge of the habits of allied species in the N. W. Himalaya it is not difficult to give, with perhaps some approximate closeness, what happens during the rest of the working season, *i.e.*, until the cold of winter sends it into hibernation and puts a stop for the time being to its destructive operations. It has been shown that eggs, the eggs of a second generation, were being laid in the trees in the latter part of June and that some of these had already developed into grubs. Beetles from this generation will probably issue from the trees about the end of July and lay the eggs of a third generation in fresh trees at the commencement of August. This generation will probably mature towards the latter part of September, issue from the trees, and lay the eggs of a fourth generation in other trees. The progress in the development of this latter generation will depend entirely on the weather. In the case of the earliest laid eggs, *i.e.*, those laid by the descendants of those beetles who got the first start in the spring, the larvæ hatching from them may proceed as far as the beetle stage and hibernate as such during the winter, whilst those of the later ones may pass the winter as grubs. In any case a certain number will probably have proceeded as far as the pupal stage when the first cold snap catches them and will probably be killed by it. It will be evident that an insect which is able to increase to this extent in any one year is a source of the gravest danger to any forest and it will be shown that this *Polygraphus* is at present imperilling the existence of the entire forest at Shinghur.

The *Phleosinus* sp. beetle.

This small beetle is easily distinguishable from the Polygraphus by its smaller oval size and black colour. Although by itself perhaps not so serious a pest as the latter it nevertheless exists in considerable numbers in the trees. A noticeable fact about this insect and one perhaps not without importance is that it will attack and lay eggs in trees which have become too dry for the Polygraphus. I do not mean that the trees are dead ones. Neither beetle will touch a dead tree but the *Phleosinus* will lay eggs in trees in which a generation of the *Polygraphus* is just maturing and emerging, although none of these latter insects will oviposit in the tree, the bark having become too dry to yield the necessary food for their larvæ. As an example of this tree No. 3, mentioned above, may be instanced. Here the Polygraphus was to be found in all stages of full grown larvæ, pupæ and immature and mature beetles, the latter of which were issuing from the tree, but there were no fresh egg galleries or eggs. On the other hand a large number of mature *Phleosinus* beetles had bored into the tree within the last week (between June 14—20) and laid their eggs in galleries grooved out in the bark. The insects were also tunnelling into the green tree No. 4.

This insect probably also commences operations in the spring, laying its first batch of eggs of the year towards the beginning of May. I only found, however, in the trees (1) mature beetles boring in in every instance to lay the eggs of what I think was the second generation of the year, (2) eggs laid by these latter and, in some cases, (3) small larvæ hatched from these eggs which had already begun to bore away from the egg tunnel. As in the case of the Polygraphus, the male insect appears to be the first to bore into the tree and commence hollowing out a chamber which grooves more or less deeply the sap wood. He is soon followed by a female and this latter by another till as many as four female beetles may have joined the male, all five being found together, at this stage, in what is apparently an enlarged pairing chamber. From this the females, after pairing with the male, eat out each a long clean irregularly curving egg gallery and lay large eggs in depressions gnawed out at the sides, one in each. These depressions are at fairly wide intervals apart, 10-12 eggs being laid about half on each side of the gallery. These galleries are chiefly in the under side of the bark of the trunk of the tree although they occasionally groove the sap wood. Plate III, fig. 2, shows a piece of bark with the pairing chamber, *a*, egg galleries, *b*; and recess, *c*, in which the eggs are laid. From the eggs young larvæ hatch out in a few days and then bore away from the egg gallery more or less at right angles to it. As I have only taken young larvæ I do not know how long these galleries are, nor where the larvæ pupate, whether in the bark or wood. The irregular winding galleries giving off all round form a figure which is usually more or less circular in general shape and is easily distinguishable from the Polygraphus galleries to which it has no resemblance whatsoever. The egg galleries are also much narrower and smaller. The pairing chamber averages ⅛th inch across whilst the egg galleries are from 1¼ to 1½ in length measured round the curves. The beetles mostly mature together and issue from the tree in a swarm. Such a swarm had evidently settled upon tree No. 3 some from it having overflowed probably to tree No. 4. Although there is not at present as much corroborative evidence available on the life history of this insect as was obtained in the case of its more dangerous *confrère* the *Polygraphus* it is probable that the *Phleosinus* runs through an identical number of generations; in fact when a generation of mature beetles of the former insect is found egg laying in the trees, search will probably show that there is a similar one of the latter at work. The fact that they prefer however drier trees and the observations made in the forest indicate that the Polygraphus is the first beetle to attack, its companion only coming in when the vitality of the tree has been lowered. As a general rule therefore it may be said that this insect, whilst preferring bark in a nearly dead, but still living, condition, will when pressed bore into and lay in green healthy trees. In the latter case it is evidently more easily drowned by the turpentine exudation than is the Polygraphus.

The *Pityogenes coniferæ* beetle.

The third beetle calling for attention is a small insect with brilliant coppery metallic wing covers. It is a branch bark-borer, confining its attentions entirely to the smaller branches and twigs of the tree. In the case of a branch bored into by all these three beetles the Polygraphus will be found confined to the lowest portions whilst the *Phleosinus* and Pityogenes will be higher up, the latter infesting quite small twigs. The work of this insect can be seen commonly all over Shinghur Forest in the smaller dead branches and twigs littering the ground. If these latter are examined they will be found to be covered with sharply cut definite patterns (I am alluding to branches from which the bark has fallen off). If these markings are examined they will be seen to consist of from 4—6 arms or galleries radiating from a common central depression; each gallery curves away from the central chamber and is marked on one side with little recesses arranged in a regular and systematic manner. The central depression is the pairing chamber, each of the radiating arms an egg gallery made by a female and the little recesses, which are from 6—9 in number and made on one side of the gallery only, formerly each contained an egg. If the bark of this twig could be examined on the inner side it would show the larval galleries giving off more or less at right angles to the egg gallery, one starting from each of the nicks and winding round the twig. At the end of the larval gallery a little enlargement is made and the larva changes into a pupa in this, the latter turning in due course into a beetle and boring its way out of the branch.

It has been shown (in Departmental Notes, page 242) that this insect probably passes through three or four generations in the year in Bashahr in the N. W. Himalaya and the latter number is more probably correct for Shinghur. The insect was found here between June 14th and 20th either (1) just maturing in the branches (the first generation of the year) pupæ and immature and mature beetles being present or (ii) the mature beetles of the first generation of the year boring into branches and laying the eggs of the second generation, many of these eggs having already hatched out into larvæ.

This beetle was only taken in the young branches. It is not improbable that it infests young saplings although such has not as yet been found to be the case by actual observations.

VIII.—Result of the Bark-borers Attacks on the Forest.

When the insects infest a tree in numbers that tree will be killed within the year. Tree No. 4 is a case in point. What is perhaps more usually the case is that swarms of the beetles fly to and burrow into the tree on one side and that side usually the one most sheltered from the sun's rays. The bark on the portion of the side infested by the beetles will die and the vitality of the tree will be lowered in consequence. Following generations either during the same or the following year will bore into the remaining area of bark and in the end the tree is killed. A careful examination of the forest showed that trees in the various stages of attack described above, in addition to numerous recently dead and long-dead and barkless stems, were to be found all over the area. The dead trees have almost all of them died under the attacks of the beetles as is easily ascertained by a glance at the trunk. If the bark is still on it will be found to be full of small holes; if it has dropped off the white stem of the tree will be seen to be covered from top to base with the beetle galleries placed so close together that it is impossible to trace individual ones.

In his report on the Shinghur Forest, written after a visit in the winter of 1892, Mr. Elliot wrote "Many trees are dead, the cause in some cases being fire in others probably the severe conditions of life, considerable heat in summer, great cold in winter, high winds at all times and scanty rainfall." Mr. Downe in a note on a visit paid in 1900 recopied this statement. It cannot however be borne out by the true facts of the case which are indelibly inscribed on the trees themselves.

The most serious point about this bark-boring beetle attack is the fact that the chief pest will infest indiscriminately both healthy and sickly trees. This family of beetles usually confine themselves to the latter, only attacking the former when driven to do so by a shortness in the supply of trees reduced in vitality. The Chilgoza Polygraphus is a marked exception and as such must be considered as forming a most serious menace to the forest and not only to the forest at Shinghur but to the neighbouring ones at Sherghali, the Takht and Spiraghar. Without wishing to be in any way an alarmist or unduly pessimistic it is not too much to say that the Polygraphus under certain, not impossibly favourable, conditions to its increase could kill off the whole of the Shinghur Forest in a few years.

IX.—The Importance of the Chilgoza Forest.

It may perhaps not be out of place here to glance for a moment at a few facts which render the Shinghur and neighbouring Chilgoza forests of such value to Zhob. The reasons, whilst few in number, are of the very first importance. Put concisely they are:—

(*a*) To preserve and increase the water-supply.

It is a fact which it would be difficult to gainsay that the springs which exist on the Shinghur range and which give water to the valleys on either side are practically entirely dependent upon the hills remaining covered with the Chilgozas. Poor as is this covering in parts it is assisted by an undergrowth of such plants as Ephreda, Berberis, ash, coteneaster, spiraea, wild almonds, dog rose, etc. It is improbable that any of these would be found upon the area in the absence of the Chilgoza forest.

(*b*) To maintain the supply of edible seed for the surrounding population.

On account of the edible qualities of its seed the tree is a most valuable one and this fact would not seem to have been fully realised in the reports existing on these forests. The question of the timber is alluded to and the demand or want of demand for the latter article is discussed. It is unnecessary that this demand should seriously affect the question, for only dead wood will be ever removed. The value of such a forest is obviously enhanced by the fact that no trees or very few need be inaccessible so far as the collection of their seed is concerned. Were this collection done in a thorough and systematic manner it would be found that the value of the forest in this respect would be 30 to 40 % greater to the village communities than it is at present, whilst at the same time seed would be available for regeneration purposes.

X.—Enemies.

The Polygraphus and Phleosinus beetles are subject to the attacks of predaceous and parasitic insect foes and it may be due to this fact that the bark-borers have not been able to increase in such numbers as to entirely destroy such a local area of trees as the Shinghur Forest represents. Trees Nos. 3 and 4 were swarming with these active predaceous foes, the insects being found within tree No. 3 and on the bark and entering tree No. 4. No less than 6 different kinds were collected, all actively engaged in feeding upon or egg laying in the bark-borers or their foes. It is probable I think that one or more of these insect enemies are predaceous upon or parasitic in one or more of the insects predaceous upon the bark-borers. They include two hymenopterous flies, an undescribed species of *Niponius*, two species of *Colydiidæ* and a species of predaceous bug, the *Niponius* being perhaps the least abundant of the six. Whilst it is impossible to deal at any length with these insects in this note a few words as to their appearance will prove a useful aid to the figures which are given of them in plate II.

Niponius sp.—This insect is undoubtedly predaceous upon the Polygraphus beetles whose galleries its own body exactly fits. It follows the Polygraphus beetles into their tunnels and lays its egg or eggs in them. One large spherical egg was taken in this manner in a gallery of the Polygraphus beetle. The Niponius larva on hatching out from the egg Probably feeds upon the polygraphus grubs.

Beetle.—Elongate, cylindrical, oblong, black and shining with the tibiæ brown and tarsi paler. The head is prominent, squarish and is covered with fine transverse striations on the anterior portion, the front margin has a deep cleft medianly; thorax with no median channel, punctured. The elytra have but few striæ, are punctured and leave two segments of the body exposed below their apices. Undersurface black. Length $\frac{5}{32}$ inch. Plate II, fig. 1 shows a dorsal and side view of this insect.

The Colydiid beetles.—The larger of these is predaceous upon the Polygraphus beetle. In the galleries of the Polygraphus I discovered numerous smallish white eggs laid several together and simply deposited on the floor of the gallery. From their position and the fact that male and female Colydiid beetles were taken together in the Polygraphus galleries I consider that these eggs are those of the larger of the Colydiid beetles and are laid in this position to enable the larvæ on hatching out to feed upon the eggs or larvæ of the Polygraphus beetles. I took a male and female of this insect together in one of the egg tunnels of the Polygraphus beetle.

The smaller of the Colydiid beetles may confine itself to the Phleosinus bark-borer or may be predaceous upon one of the enemies of the bark-borers.

Beetle.—Light brown in colour with a prominent head, furnished with large black eyes and short antennæ, the thorax is square and pitted as also are the elytra which leave the tip of the body exposed. Plate II, fig. 2 shows the larger of the two Colydiid beetles.

The *Hymenopterous* flies.—These flies are probably species of the family *Chalcididæ.* They lay their eggs either in or amongst the eggs of the bark-borers or in or on the grubs. They were to be found numerously in the trees and their grubs evidently do not kill the grubs of their hosts until they have become full fed and eaten out the pupal chamber, since the pupæ of the flies were often found in this position.

They are deep metallic blue in colour with green reflexions, the head and the thorax being dull coppery. The eyes are brilliant crimson. In the larger of the flies the wings have a transverse brown band across them about halfway up. Plate II, figs. 3 and 4 show these two flies.

The black bug (*Hemiptera*).

The last of the predaceous insects taken is a small elongate, narrow, flat, shining, black bug furnished with a long, strong, 4-jointed elongate, black proboscis the last segment being pointed and yellowish. This projects from the top of the head which is small. The wings are membranous and palish yellow, the upper being folded across the lower. The thighs of the legs are thickened and black the rest of the legs being yellowish. Length ⅛th inch excluding the beak.

This little bug was very plentiful in the trees and is most probably, I think, predaceous upon the Polygraphus grubs, pupæ and beetles. (*vide* fig. 5).

XI.—Protection and Remedies.

The question of protecting a forest from the depredations of its insect foes is often a difficult one in India owing to the immense areas which are usually involved. In the present instance, however, conditions are to a certain extent favourable owing to the more or less isolated position of the forest and, in a lesser degree, to the nature of the insects which are committing the damage. For although bark-boring beetles (Scolytidæ) are capable of doing immense damage in a forest (some 15,000 fine spruce trees have been recently killed out in the Vosges mountains in France by species of these insects) once their life histories have been worked out and understood it is usually possible to cope with and stamp out an attack although, in effecting this, considerable sacrifices have occasionally to be made. It must be borne in mind, however, that when sacrifices have to be made, *i.e.*, large areas of trees have to be felled before their time and removed owing to the attacks of the insects, it is invariably due to the fact that the beetles have passed unnoticed in the area until they have increased in such numbers as to entirely gain the upper hand. An attack of bark-boring beetles usually commences from a centre and radiates outwards in all directions. If the initial attacks are marked down it will mean the removal of only a few trees. If they go unperceived for some time a forest may have to be felled to stamp out the pest.

To return to the present case: Shinghur is a virgin forest untended up to date by man. We have seen that it is of an open character on the south becoming densest in its northern part. As is usually the case under natural conditions, the beetles are to be found all over the area but for some reason they appear, and the proof of this statement is to be read in the dead trees, to be becoming year by year more aggressive, *i.e.*, they are increasing in numbers. A probable reason is that the Chilgoza seed has been collected with more regularity since the British have been in the country and that this more intense collection has resulted in a greater number of men frequenting the forest and to a greater amount of damage being done to the trees in consequence, thus providing the beetles with a larger supply of easily-got-at food material. Grazing and its concomitant damage has also certainly been more intense than was the case when the forest first began to occupy the area. In considering measures for endeavouring to stamp out the pests or for reducing their numbers to a point at which they will no longer be harmful it will therefore be needful to remember that the forest must be treated as a whole and the entire area carefully taken in hand and worked over.

We have seen that the signs of attack are easily observable on the outside of the trees in round shot holes usually surrounded by a ring of resin to which wood dust may be sticking, and in pear-shaped blobs of turpentine or long trickles of this substance being present beneath the shot holes.

1. The first recommendation is therefore—Search through the area and mark all trees showing this appearance over at least half the circumference or more of the bark of their stems and large branches. To ensure this search proving successful it should, as far as possible, be carried out during the periods at which the beetles are boring in to egg-lay, for the resinous exudations will then be quite fresh. The search should therefore be made about the beginning of May, again in the latter half of June, during the first half of August and lastly about the middle to the end of September.

2. Having marked the infested trees the next question is their removal. This removal is effected not because the wood of the tree will be of value, since here it will probably be unsaleable, but primarily with the object of destroying all the insects within it. We must, therefore, choose the most suitable time for effecting this object and this will be when all the beetles have ceased boring in to egg-lay and *before* any of the beetles arising from the eggs have matured sufficiently to leave

the trees; in other words, the ideal time to cut the tree is when the insects inside are in their larval and pupal stages. It has been shown that the generations of the beetles overlap to a certain extent, so that this ideal state is rarely obtainable. Our business is, however, with the greater number of the insects, *i.e.*, with the bulk which issue at the normal time for the different generations. From the life history we see that these periods will roughly be about the beginning of June, middle to third week in July, end of August and second to third week in October. Of course the exact periods will vary to a certain extent according to whether the year is a dry warm one or a wet cold one and will be dependant on whether the spring was an early or late one. The test is to cut into the infested tree and remove a strip of bark of several inches in length. If the insects in the bark and sap wood are mostly-full grown, white grubs, and white pupæ with a sprinkling of light yellow soft immature beetles, the time for cutting the tree has arrived. The great object is to never allow the light, yellow, soft, immature beetles to get beyond that stage. If they have become dark in colour and hardened, some will be certain to escape from the tree and lay their eggs in other trees.

3. Having ascertained that the insects in the tree are in the right stages for felling, fell the tree and remove and burn every portion of the bark and pile up and burn all the branch wood. By doing this all the insects it contains will be caught and destroyed.

The above operations will suffice to clear Shinghur of the bark-borers or to so reduce their numbers as to render their attacks ineffective. It should, however, be most carefully borne in mind that the very greatest circumspection must be used in—

(*a*) Selecting the trees for felling.
(*b*) Felling them at the right time.

The reasons for (*a*) are obvious since the tree is valuable on account of its seed and not for its timber and therefore produces an annual income which, once the tree is felled, ceases. That it is essential that the infested trees should be removed is owing to the fact that whilst they themselves will die under the beetle's attack other trees will become subsequently infested from the insects they rear up and will be killed in their turn. (*b*) The felling at the right moment is necessary because otherwise the benefits to be obtained, *i e.*, the large number of insects destroyed and the consequent diminution in the number available to do further damage in the forest, will be lost.

Whilst therefore inadvised fellings, from a careless selection of the trees to be felled, will result in an unnecessary loss in the annual income from the forest, the omission to remove trees seriously infested with the beetles will result in greatly lessening the value of the fellings made and will necessitate further removals of trees in the year or years following.

XII.—Points in the Life History requiring further Observation.

1. The first and important thing is to ascertain definitely how many generations each of the beetles pass through in the year· Is it three, four or, in warm early springs followed by a hot summer, five?

2. A confirmation of the observations already made upon the life histories of the *Polygraphus, Phleosinus* and *Pityogenes* beetles.

The life history of the Polygraphus, the most dangerous of the three, is now practically known with the exception of the important point about the number of generations and the same remark applies to the Pityogenes.

On the subject of the Phleosinus the position of the larval tunnels has to be ascertained in addition to the number of generations passed through, etc.

3. The area over which the insects are spread—At present no information is available as to whether the bark-borers are present in the larger Chilgoza forests at Shergali, on the Takht and at Spiraghar. It will be important to ascertain this so as to definitely settle the present range of these pests.

G. I. C. P. O.—No. 1692 R. & A.—1-12-1905.—1,700—J. N. S.

PLATE I.

Polygraphus Trenchi, n. sp.

IG. 1. Side view of larva.
" *1a.* Ventral view of pupa.
" *1b.* Female beetle, dorsal and side view.
" *1c.* Front view of head showing the curved brushes of stiff hairs.
" *1d.* Antenna of ♀ enlarged.
" *1e.* Male beetle, dorsal and side view.

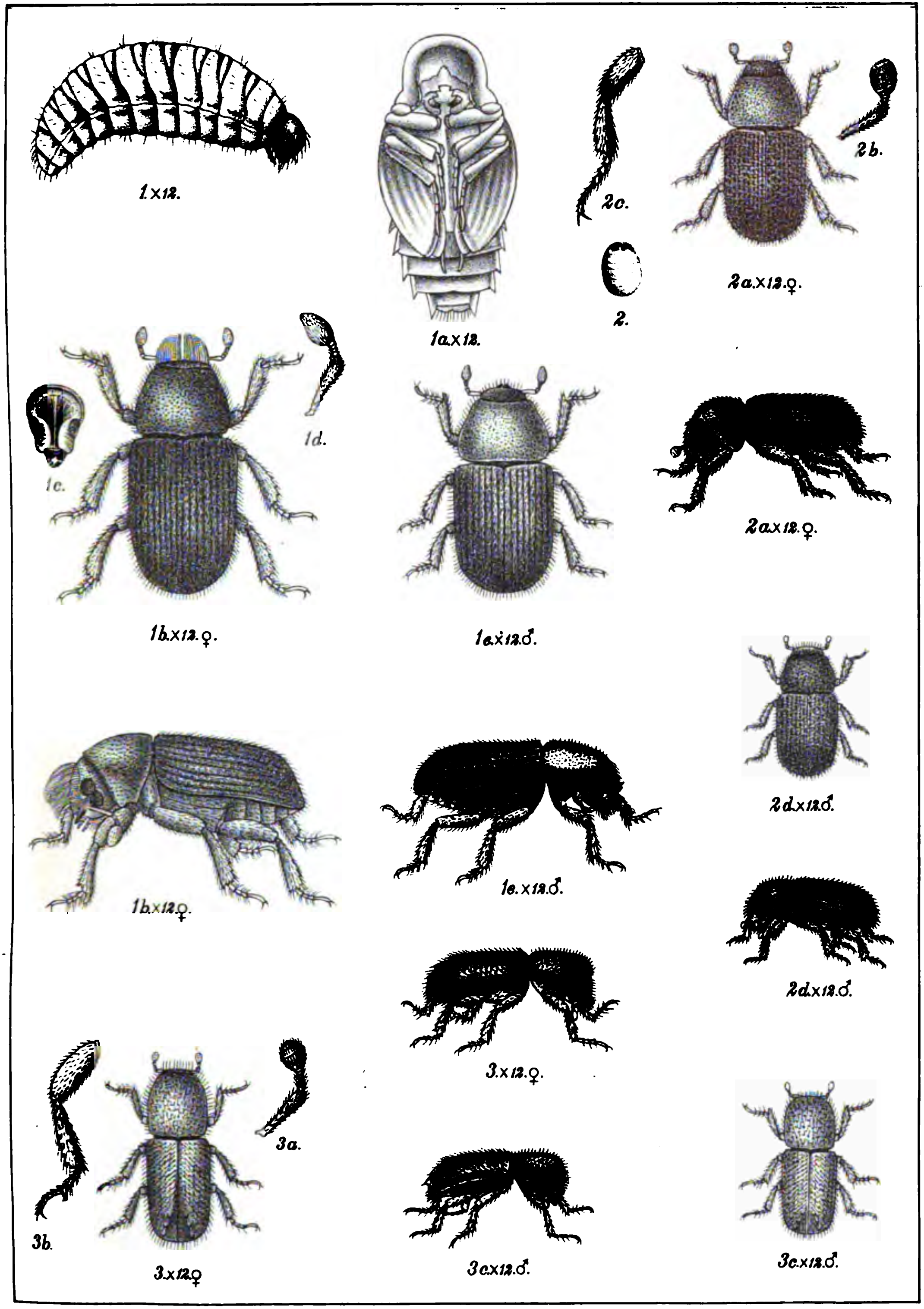
Phleosinus sp.

FIG. 2. Egg.
" *2a.* Female beetle, dorsal and side view.
" *2b.* Antenna of ♀.
" *2c.* Leg of ♀.
" *2d.* ♂, dorsal and side view.

Pityogenes coniferæ, Steb.

FIG. 3. Female beetle, dorsal and side view.
" *3a.* Antenna of female.
" *3b.* Leg of female.
" *3c.* Male beetle, dorsal and side view.

NOTE.—All the figures are magnified 12 times.



S. B. Mondul, del. Lith: by S. C. Mondul.

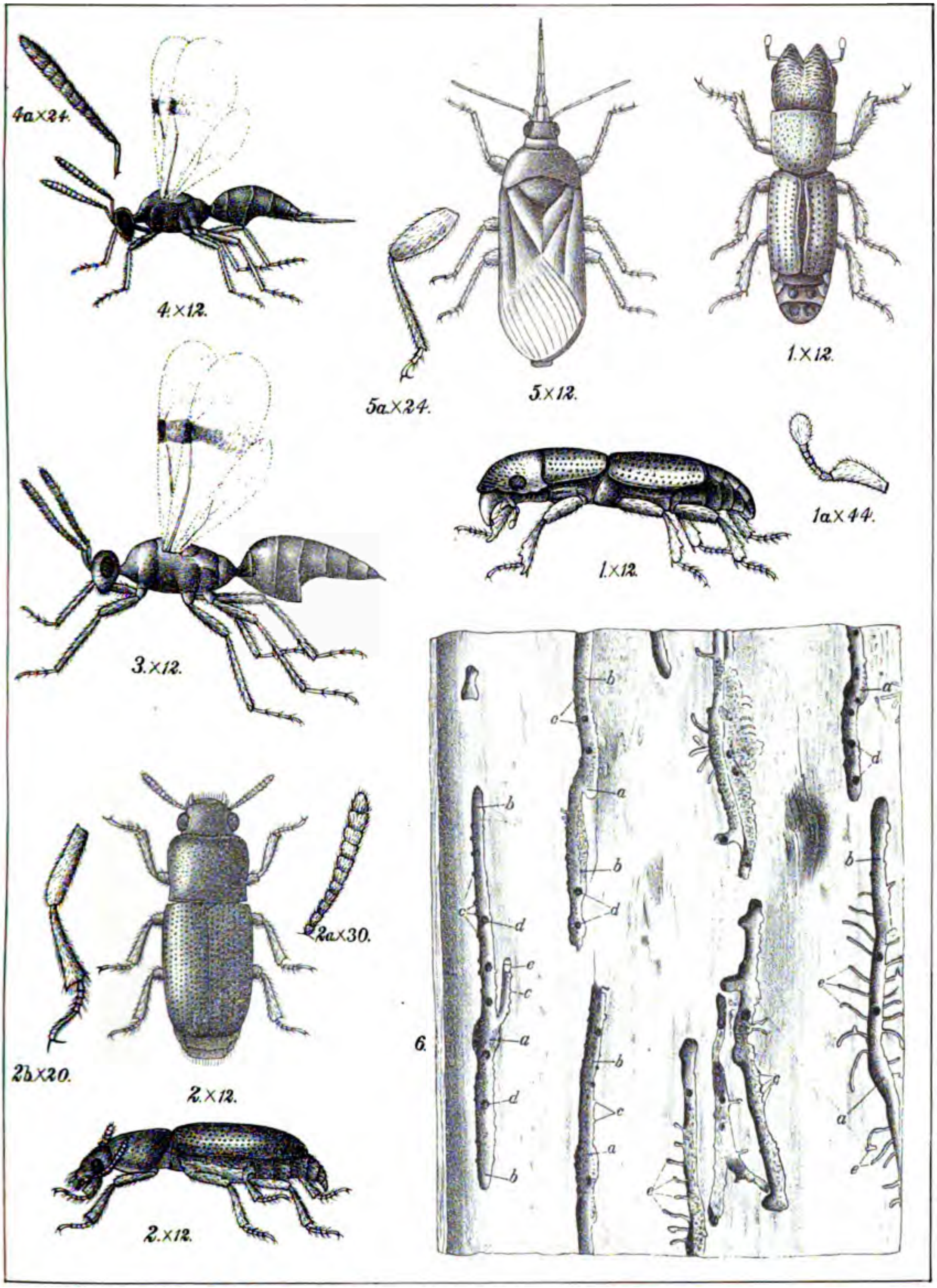
The Chilgoza (Pinus Gerardiana) Bark-borers.

PLATE II.

FIG. 1. Niponius sp. Dorsal and side view of beetle.
1a. Antenna enlarged.
„ 2. Colydiid beetle (large one), dorsal and side view.
2a. Antenna enlarged.
2b. Hind leg enlarged.
„ 3. Hymenopterous fly. (*Chalcididæ ?*).
„ 4. Hymenopterous fly. (*Ditto*).
4a. Antenna enlarged.
„ 5. The black Hemipterous bug.
5a. Leg enlarged.
„ 6. Piece of bark showing egg galleries with egg recesses made by *Polygraphus Trenchi*. *a*, pairing chamber; *b*, egg galleries; *c*, egg recesses; *d*, air holes; *e*, larval galleries.

NOTE.—All the insect figures are magnified 12 times.

Stebbing - Note on the Chilgoza Bark-boring beetles of Zhob. PLATE II.



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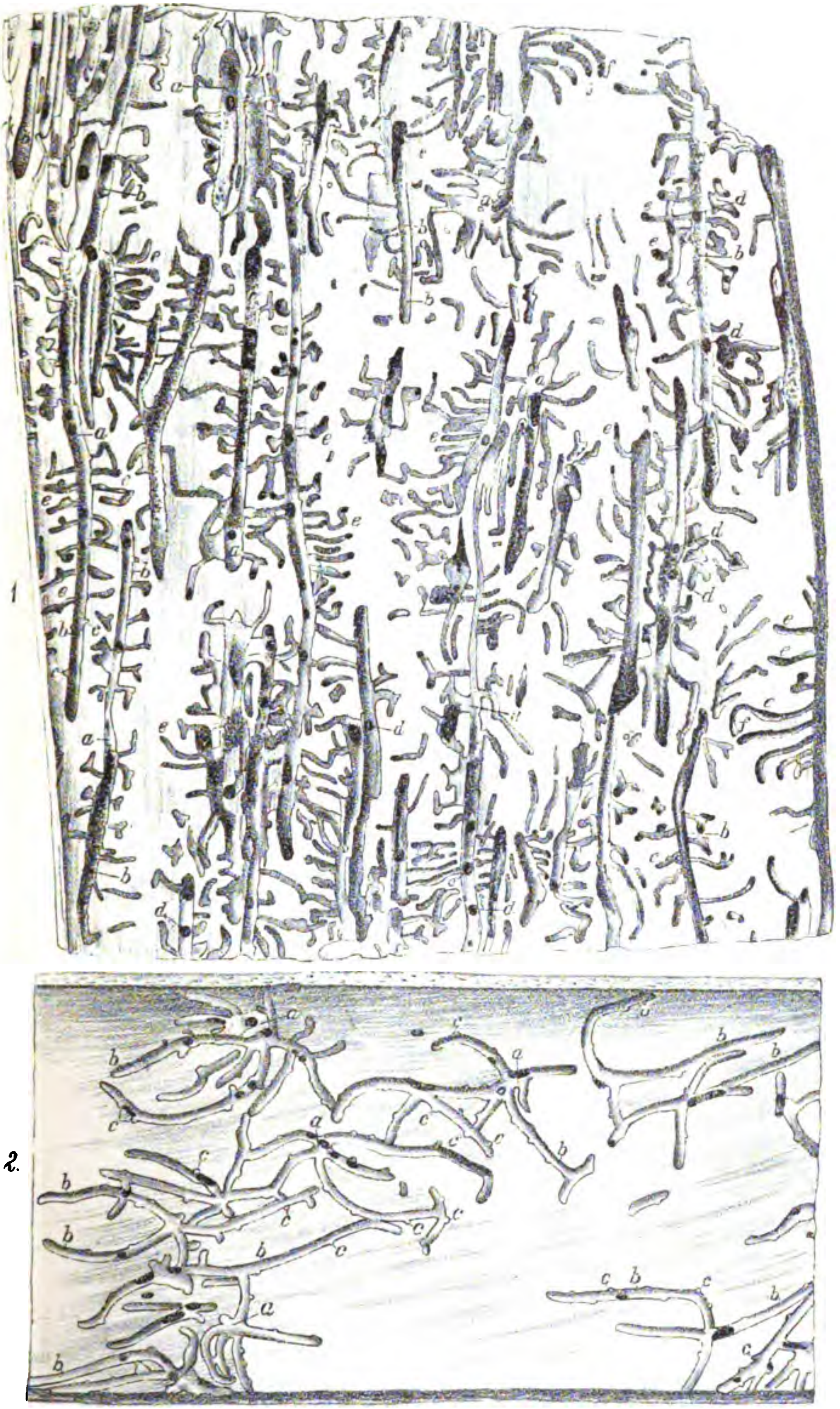
The Predaceous and Parasitic Insects of the
Chilgoza Bark-borers and the egg galleries
of Polygraphus Trenchi.

PLATE III.

FIG. 1. Piece of bark badly attacked by *P. Trenchi*. *a*, pairing chamber; *b*, egg galleries; *c*, egg recesses; *d*, sair holes; *e*, larval galleries; *f*, pupating chamber.

" 2. Piece of bark attacked by *Phleosinus* sp. *a*, pairing chamber; *b*, egg gallery; *c*, egg recess.

Stebbing - The Chilgoza Bark-boring beetles of Zhob. PLATE III.



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Clilgoza bark showing the borings of the bark-boring beetles.

Forest Bulletin No. 4 1906.

FICUS ELASTICA:

ITS NATURAL GROWTH AND ARTIFICIAL PROPAGATION.

WITH A DESCRIPTION OF THE
METHOD OF TAPPING THE TREE AND OF THE PREPARATION
OF ITS RUBBER FOR THE MARKET.

BY

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G. I. C. P. O.—No. 311 I. G. For.—30-6-1906.—1,000.—P. M. M.

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by correlation of factors that we are not as yet cognizant of. But this much is certain that it is found growing in abundance on the Lounau hills at an altitude of 5,200 feet and is reported from high altitudes in the Jan Mun Bun mountains to the east of N'tupusa on the north and south watersheds of the Taron river, the higher crests and peaks of which are covered with large masses of snow in the winter. It does not appear to actually grow in places which are subject to snow-falls, but is found in all the damp, deep gorges on the slopes of such hills, very often creeping up the latter to considerable altitudes.

If the tree does not actually grow high up in the mountains, it yet must experience severe winter frosts, but it is probable that the influence of the latter is modified to a certain extent by the position of the seedlings on the stems of their hosts, and they very likely do not suffer to the same degree as they would if growing on the surface of the soil.

The trees planted at Shillong, elevation 4,000 feet, died during the severe winter of 1904-05, but as on this occasion indigenous trees over many hundreds of square miles were killed by frost this evidence is far from conclusive.

Description of the tree.

3. A gigantic, evergreen tree (often 100 to 120 feet in height) sending down numerous aerial roots from the branches, it is easily recognised by its large glossy leaves and, during the growing season, by the large red stipules which surround the leaves and which drop off as the leaves unfold. At Charduar the natives distinguish two varieties—Bogi Bor and Shika Bor. The former is affirmed by them to be the better and has much larger leaves than the other.

Natural method of growth.

4. The tree is essentially a light-demanding species and, though an evergreen and associated with and growing amongst dense shade-bearers, no tree can be more exacting in its demands for light. Wherever it is surrounded with dense shade it will be found that this tree, in order to escape from it, has grown to enormous heights, in many cases towering head and shoulders above every other tree in its vicinity.

Seedlings grow as a rule in the fork or crevices in the bark of the light-foliaged trees (Dalbergia, etc.) at a great height from the ground and occasionally on the half-rotten trunks of dead and dying trees in places where from windfalls or otherwise clearings have been formed in the leaf canopy. The young seedling thus obtains a good start over its rivals in the struggle for existence.

The young plant remains an epiphyte for years until its aerial roots touch the ground: as soon as this takes place, the little epiphyte changes rapidly into a vigorous tree, throwing out numerous aerial roots which gradually envelope the tree on which it first began life and often kill it. Having started life so high up, it is able to throw out branches which overtop the surrounding trees, and the numerous aerial roots which fall from these and establish connection with the ground enable it in a few years to dominate the forest growth around it.

In accordance with its light-demanding character seedlings growing on the ground are extremely rare. That they will grow on the ground is, however, proved by the seedlings found in tea gardens where the ground is kept clear. Also trees which have originated from seed that has germinated on the ground are said to be not at all rare in the Aka Hills.

Underground roots.

5. In 1892-93 and the two previous years attempts were made to kill out the suppressed rubber trees in the Charduar plantation by tapping them heavily. However, on examining the roots it was found that those of neighbouring trees had anastomosed, so that the plantation had practically become one huge tree. The roots spread out near the surface of the ground to a distance of 150 feet or more. Those of "gooties" or Chinese grafts and cuttings are rather brittle and snap off, if planting is not carefully done.

Aerial roots.

6. The vigour of a tree may be gauged by the number of its aerial roots, even seedlings soon establish their connection with the ground by numerous aerial roots. The aerial roots will anastomose with one another or with any part of the trunk or branches with which they may come in contact and such a root of one tree may even join on to the branch of another. In 1897-98 one of the large aerial roots of a rubber tree in the Charduar nursery, which in its descent had anastomosed with another aerial root of the parent tree, was severed at its upper end, since it did not die this proved that it had completely anastomosed. Numerous roots are also put out from the edge of the cuts made in the tapping operations and these often establish connection with the ground within a year. Also, if aerial roots are inserted in split

bamboos filled with earth, they quickly reach the ground and rapidly increase in size.

Seed and fruit.

7. The seed is contained in a fig-shaped fruit, the size of a pea, about 75 seeds, the size of a pinhead, being found in one good, sound fig. The fruit first begins to form on the trees in March and ripens from May onwards to December. On some trees the whole crop ripens and falls off by June, but, as a rule, the tree has fruit on it from April to December, the figs forming, ripening and falling off during the whole of the rainy season.

Description of seedling on germination.

8. The embryo appears on the germination of the seed as a seedling having a pair of opposite cotyledons with an entire margin, destitute of incisions or appendage of any kind, with the exception of the notched or emarginate apex, oval in general outline, green in colour and of a glassy smoothness. The second pair of leaves shows a tendency to the alternate arrangement on the stem, but appear at the same time. Their shape and v~~ariation~~enation are very different to those of the primary leaves, for they have a central midrib and a distinctly coarsely crenated margin. The third pair of leaves do not appear simultaneously and are distinctly alternate, with a marked reddish colour: after this period is passed the plant is easily recognised.

(ii) ARTIFICIAL PROPAGATION.

(a) Various methods described.

Requirements of young rubber plants.

9. The general conditions for the healthy and rapid growth of the young trees of Ficus elastica are:—

(1) Perfect drainage about its roots and looseness of soil so as to admit the air readily, the composition of the soil not so far as is known seriously affecting the trees as long as the above conditions are fulfilled: but gravel or sand does not appear to be suitable since all the caoutchouc collectors state that the trees produce much smaller quantities of rubber when grown in such soil even in the best localities.

(2) Plenty of light.
(3) Heat and moisture combined, or what is commonly termed a close, steamy atmosphere.

There seems in short to be no doubt as to what is required to make this ficus thrive and this may be summed up in the few words, air, light, good drainage about the roots and as much moisture in the air as possible.

The last condition, of course, is very present at the foot of mountains which is the situation of Charduar, and this is encouraged by only clearing lines through the forest at a hundred feet apart and leaving the natural vegetation standing between these lines. Another very necessary requirement to ensure plenty of air and light is the constant clearing of the dense scrub round the young trees which grows with marvellous rapidity. The drainage about their roots is ensured by planting on mounds.

It has been asserted that the rubber tree grows equally well on high land or low land, in forest land or grass land, so long as it is planted on a mound and its roots are not exposed to the sun; and that it is a surface feeder, but, as soon as its roots appear above ground, they must be covered with fresh earth until such time as the tree has formed a sufficient leaf canopy to protect itself. But the statement that the tree grows equally well everywhere cannot be accepted as correct. In the first place it does not grow well in swampy ground, or in places where water stands for a large part of the year, *e.g.*, the trees planted on mounds along the Dhekrigaon road which is bordered by rice fields have hardly grown at all, though planted in 1879-80, and many of them have died. Where the trees are in low places, with water on the ground the greater part of the year, it does not suit them even though they have been planted on mounds. They then become sickly and will probably die in a few years. Floods have occasionally killed all the seedlings in the nurseries.

In the second place rubber does not appear to grow well in grass lands where there are no trees. Most of compartment 18 consists of land of this description and the plants here are very sickly and have hardly grown at all and probably will not come to anything. Many have died. This may be due to absence of shade; but the composition of the soil of such lands is probably unsuitable to the growth of trees.

Propagation by layers.

10. Experiments made in 1897-98 showed that rubber can be easily grown in this way.

Cuttings.

11. The tree can readily also be propagated from cuttings if only perfectly ripe young branches or shoots are used, but the trees raised from cuttings do not appear to throw out aerial roots, and, as the future yield of the tree probably depends on the number of these roots, it is questionable whether trees raised from cuttings should be used except where required for shade as in an avenue. In the Charduar plantation propagation by cuttings was given up very early, that is after 1876, the plantation having been commenced in 1873.

The best time for making cuttings in Assam is, no doubt, from the middle of January to the end of May, it depends on the rainfall during the latter three months which of the cuttings will do best: those made in 1874 after May failed almost entirely. The earlier in the season before the trees from which the cuttings are obtained have started growth the better chance the cuttings have of success. At this time young terminal shoots will grow well whilst, after the trees from which the cuttings are taken have commenced growth, which happens about the end of January, the lower, somewhat harder portion of the young branches succeeds better than the soft terminal shoots. Only young and vigorous branches from lopped trees are used, and they are cut from one to two feet in length and are put three inches in the ground. All scrubby branches from old trees almost invariably fail. The branches of young trees succeed better than those of lopped trees.

In 1875 the preparation of cuttings was begun at the end of January and continued till the middle of March. They were planted on raised beds. Artificial shading of grass was employed, the shades being removed every afternoon and not replaced until about 9 A.M. In the middle of March rain fell and continued for some time when opportunity was taken advantage of to harden off the cuttings and to remove the artificial shading. Until rain fell all were watered twice a day. Whilst cuttings form at once larger plants and grow faster during the first year or two, seedlings are hardier and stand transplanting better than cuttings. It appears to be inadvisable to transplant cuttings till they are two years old. Cuttings from vigorous top-shoots cut and put in the ground before they have started new growth in December and January make roots readily.

In ~~1895~~ 1905 large cuttings, twelve feet in length, were used. All the green parts were cut off and they were fixed two to three feet in the ground. They were planted on mounds and tied to stakes. A few were planted in March after heavy rain, as an experiment, and the remainder in May and June. Of 21 cuttings planted in March to fill up vacancies one has died, or 5 per cent.: of 82 planted after the rains had well set in, 23 died, or 28 per cent. Several cuttings were planted in May, before the rains began, and whilst it was very hot, but these nearly all died. From the above it would appear best to plant cuttings before the growing season commences, that is before the end of March.

Gooties.

12. Gooties or Chinese grafts have been used since 1902-03 for filling up blanks in the plantation. To prepare gooties, vigorous young branches 12 to 20 feet long are selected, those still covered with red bark probably giving the best results. A strip of bark 3 to 8 inches wide is then removed, care being taken not to injure the wood, at the point where the roots are wanted, and this should be at least 9 inches above where it is proposed to saw off the branch in order to allow the gootie to be firmly fixed in the mound. At the point in the branch where the bark has been removed a large lump of wet clay, mixed with cowdung, is tied on with a piece of gunny cloth and kept wet till such time as small root-lets appear through the cloth when the gootie is ready for planting out. During the rains the roots appear in about three weeks to a month's time, and in Assam the best time for preparing this form of graft is April and May; they should be planted out during May and June.

The gooties should be planted at least 2½ feet to 3 feet deep in the mound and should be tied to stakes as in the case of seedlings. It is not yet known whether gooties are likely to give successful results. Out of 83 gooties carefully planted in compartment 12.C. in the rains of 1904, 21 died, or 25 per cent., while those gooties planted in other compartments have mostly failed. They usually dry off at the top and consequently pruning of the ends of their branches might have good effects.

Seedlings planted in the forks and on the branches of trees.

13. In imitation of the natural method of growth seedlings have been planted on the branches of trees but the growth is very slow until the roots reach the ground after a number of years; and this method of cultivation has now been abandoned. Experiments

were started in 1875 to plant the young trees in strongly made cane baskets and to place these in the forks of trees. Only seedlings were used for this mode of planting, because they form thick tuberous roots and thus are more fit to cope with the comparative dryness to which they are exposed in the tops of trees in the dry season. The first of these was planted on January 25th in trees near the nurseries and up till the 21st April they looked everything that could be desired; in all 400 plants were put out, but in May 1905 only one survived. It appears that in the three years following the planting the seedlings either remained stationary or made one or two leaves only, which is attributed to the want of moisture in the soil provided in the baskets and also to shade from above which is necessary in order to retain some moisture in the soil. Thus on the one hand to prevent excessive evaporation shade is required and on the other the presence of shade is prohibitive to the growth of the seedlings. The cost of stocking the plantation by this method amounted to about Rs. 5 per acre, but, as before noted, the system has been abandoned as unsuitable.

Planting on split stumps, etc.

14. Before the system of planting on mounds was established, seedlings were planted experimentally on split or hollow stumps of trees. The planting on split stumps of trees and in earthenware tubes placed on stumps proved very successful in low situations, counteracting the effects of excessive moisture; but vigorous growth was not attained without the admission of light. The trees planted on low split stumps, or in earthenware cylinders placed on stumps or on piles of wood put crossways and mixed with earth, or on small mounds of earth about 2—3 feet in height all succeeded well in the lines cleared through the forest, and this being so all plants are now planted on mounds of earth, raised about 3 feet above the ground, this being found to be the most economical way of working. In Upper Burma experiments have been made to propagate the species by placing cuttings or seedlings in hollow teak stumps, which are previously filled with earth, in moist or evergreen forests, and they are found to grow vigorously and are out of the reach of animals. It has been found that better results are obtained from the planting of young, well-rooted seedlings than of cuttings. Seedlings are, however, difficult to obtain and are expensive, the Kachins who supply them being paid about twelve annas to one rupee a plant. Several hundred

seedlings have been planted out and in 1904 were reported to be growing vigorously.

(b) Reproduction by nursery seedlings.

Collection of seed.

15. Seed should be collected from trees over 20 years old, but not over-mature, as experience has shown that seed collected from younger trees will not germinate. It is advisable to gather seed from beneath the trees when the figs are ripe and birds have begun to feed on them. The bird droppings and ripe figs found on the ground should be swept up daily, since the seed that has passed through the alimentary canals of birds germinates best. The seeds thus collected may, however, contain other varieties of fig which ripen at the same time, but very soon after germination different varieties are easily recognised and can be weeded out. The sooner after collection the seed is sown the better, but if seed has to be kept, the figs should be carefully dried and mixed with pounded charcoal, which preserves it for many months.

Preparation of the nursery.

16. A site should be chosen for a nursery where the soil is good and there is some shelter, and a well or stream should be near so that the plants can be watered. The land selected should be ploughed up and allowed to lie fallow for some time to prevent the growth of moss, etc. It should then be watered and levelled, all stumps and roots being removed, and finally drained and fenced. The seed beds should then be prepared while the rest of the nursery is marked off into beds to receive the transplants. All the beds should be raised one foot, having small paths between them, and for the seed beds good soil containing vegetable matter should be brought in.

Preparation of the seed-beds.

17. To prevent the soil of the seed-beds being washed away, small pegs are driven into the ground along the outer edge of each bed against which some reeds are tied horizontally and thatching grass is then put on the inside of the reeds. The soil should be pulverised and passed through seives and levelled, then 3 inches of charcoal dust should be spread over the beds and mixed up with the soil by hand. The beds are then smoothed down and are ready for sowing. Light sandy soil is the most suitable for seed beds: if the soil is stiff, charcoal-dust or river-sand should be

mixed with it to make it porous and prevent caking. The seed beds must never be allowed to get dry.

Shades for the seed-beds.

18. Light, movable shades are put up over the seed-beds to intercept the direct rays of the sun and to prevent the seed being washed away by rain; they are removed at night and during cloudy weather. They may be made of thatching grass or bamboo mats. When planting operations were started, it was found during the first few years that seedlings died in large numbers, and in 1877-78 a side-shade, 7 feet high, was put up vertically along the Southern edge of the beds, and it was noticed that wherever the sun got at the seedlings over the top of the shade, they were all killed. It is believed therefore that shade is absolutely necessary for the young seedlings for some time after germination. It was also found by experience that seedlings and cuttings were very susceptible to injury from too much shade or drip from the trees left in the nursery causing excessive moisture about their roots, and that artificial shade over the seed-beds caused drip and excessive moisture which proved fatal to many seedlings. Consequently, the seed-beds must not be allowed to become too damp, but on the other hand the seedlings must be protected from the sun.

Method of sowing.

19. At present seed is sown as follows:—For a seed-bed, 40′ × 3½′, two to three seers of broken figs, 10 seers of ash and 20 seers of vegetable loam or good soil are well mixed, about a pint of kerosine oil being added to prevent ants and other insects carrying off the seed. This mixture is spread evenly over the bed and then lightly tamped down and watered. Such a bed should yield with good germination 2,000 seedlings and should be sufficient for planting up 100 acres of rubber. The figs are broken between the hands and as the seed is very minute, the particles of the fruit are left with the seed and sown with it, no attempt being made to clean the seed by separating the pulverised fragments of the figs.

In 1874-75, 30 seers of fruit were sown in three different ways:—

1st.—On beds covered with broken bricks, half of which was sown with entire figs and the other half with the fruit broken up or rubbed into powder between the hands.

2nd.—Sown like the above, but on broken charcoal.

3rd.—Sown like the above, but on earth only.

E. M. COVENTRY—FICUS ELASTICA.

PLATE II.

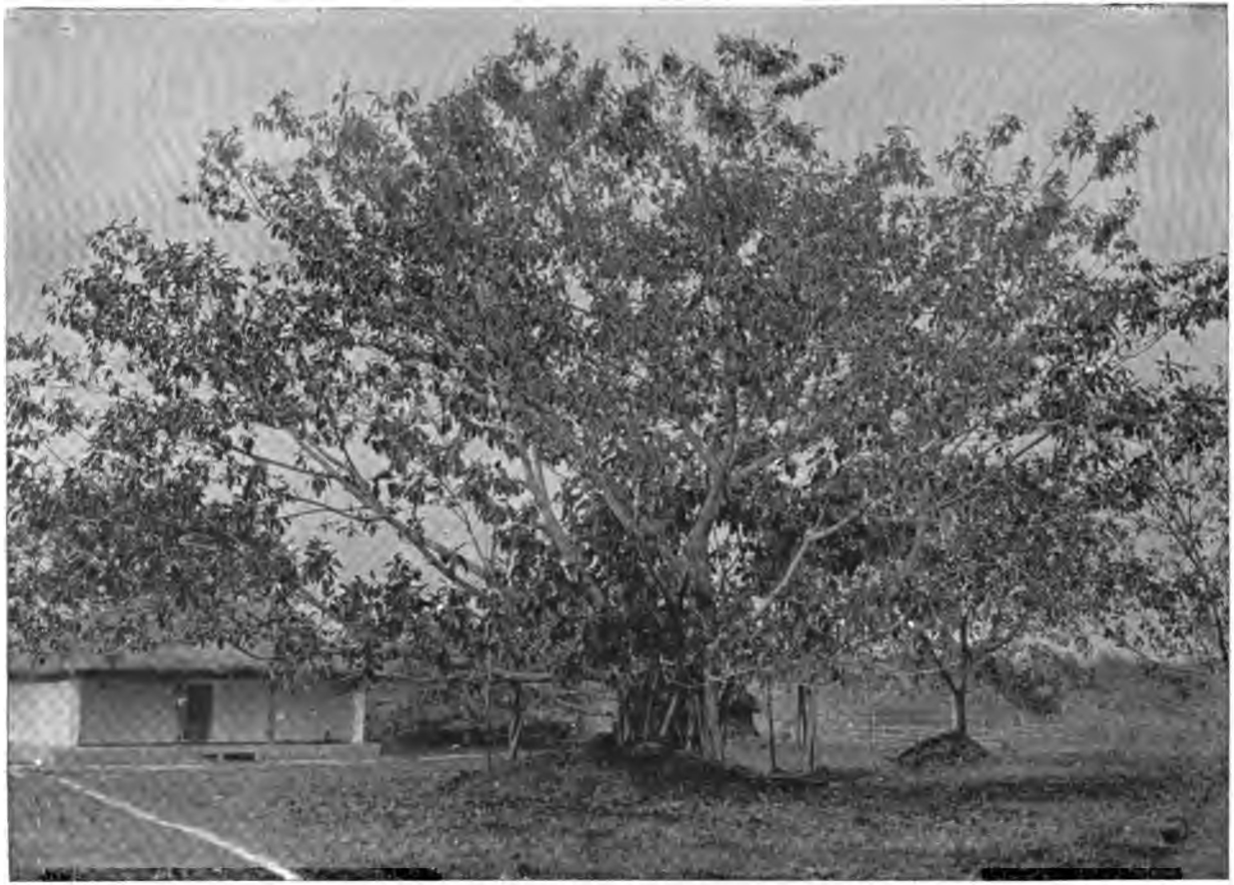

Photo.-Mechl. Dept., Thomason College, Roorkee.

E. M. Coventry, Photo.

PLANTATION TREE, 55 FEET HIGH, ABOUT 15 YEARS OLD.

The seed was sown in the middle of January and germinated in the middle of April. Germination took place best on the broken bricks, next best on the charcoal and least on the earth. When the rains set in heavily, the seedlings on the charcoal stood it best, those on the broken bricks next, whilst those on the soil nearly all perished. These beds were not shaded. There was no difference in the germination of the seed when the whole fruit had been sown and the fruit had been crushed, except that in the former case the seedlings were very much crowded.

A similar experiment is described in Gamble's "Manual of Indian Timbers." In this case the germination was best on garden soil, next best on the broken bricks, and last, though still very good on the charcoal. Here, however, the beds were irrigated and shaded.

In 1877-78 another experiment was made. Seed was sown on 33 beds. Of the above beds, one was prepared with earth only, without charcoal, and produced 3,011 seedlings, 20 beds were prepared with rather coarsely-broken charcoal, and the latter but slightly mixed with the soil. These produced an average of 707 seedlings to each bed: 12 beds were prepared with very finely-broken charcoal well worked into the soil and produced an average of 1,864 seedlings on each bed. The beds were shaded.

In 1879-80 30 beds were prepared: 5 consisting of plain earth well dug and cleared of roots and weeds: 18 others where the soil was mixed with charcoal as heretofore: and in the remaining beds manure was used.

Whilst on the beds of plain earth the weeds and moss came up very profusely, those in which charcoal was used were comparatively free from either weeds or moss, and on those beds where manure has been used, the number of plants that came up was very much less than on the other beds, but the seedlings looked more vigorous.

In 1896-97 lime was mixed with the soil of one of the beds. In this bed after germination the seedlings pushed far ahead and were fit for pricking out long before the others. This experiment does not appear to have been repeated.

Season for sowing.

20. Germination takes place from the end of April to the end of the rains. Seed sown between October and January requires daily watering and screening from the sun and will not germinate before the end of April

or the beginning of May, but seed sown at any time during the rains will germinate in a few days, from five days to a fortnight. It follows that the best time for sowing seed is during the rains, that is, from June to September. Seed might be sown in May, but the weather is generally too hot then. Previous to 1897 seed was sown in the cold weather months, but from that year it has been sown during the rains. In that year seed was sown weekly during the rains. After September 27th very few seeds germinated, and after October 4th germination ceased. It has, however, been found at Charduar that a good deal of the seed germinates in the following, or even the second, year after sowing.

Weeding and watering.

21. The seed-beds must be kept clear of weeds and watered when necessary, as they must never be allowed to become quite dry.

Transplanting.

22. When the seedlings are one to two inches high in the seed-beds they should be transplanted into nursery-beds and put out in lines about a foot from each other. The nursery-beds should be well raised and drained, but the soil need not be so carefully prepared as for the seed-beds. Here the plants are kept till the following rains, when they are dug up and taken to stockaded nurseries in the forest, and put out 5' x 5' on raised mounds where they remain until they are large enough to plant out.

About ten days or a fortnight before the transplanting takes place the shades should be removed from the seed-beds, so that the seedlings may be hardened off. If this is not done, the seedlings are liable to be killed by the sudden exposure.

Season for transplanting.

23. When the plantation was started and during the first ten years, transplanting appears to have been done in the cold weather. The report of 1875-76 states that the best time for transplanting appears to be November and December, before the winter rains. In the following year it was thought that October was the best month. But experiments made in 1878-79 showed that transplanting can be done at any time of the year, provided that ordinary care is exercised and the roots of the plants are not damaged. During dry weather watering would be necessary. In this year twelve plants were put out each month and they all did equally well. At present transplanting is done during the rains, and this is

necessary when large plants, 10—12 feet high, are used, since damage to their roots is unavoidable. The best time in Assam is perhaps between May and July.

Forest nurseries.

24. To avoid the carriage of seedlings for long distances, it is advisable to establish forest nurseries near the areas which are to be planted up. Almost every animal will eat the young rubber plants ; it is, therefore, impossible to plant out small seedlings in the forest, owing to the destruction by wild animals and deer, which will break down plants up to 10—12 feet high, unless each individual plant is fenced in or tied to stakes. This was done when the plantation was started. Fences of plaited bamboo costing 2 to 4 annas each as well as other kinds were used. But these proved insufficient to protect the plants, and in 1878-79 a strong fence was made right round the plantation with the object of keeping out deer. This was very costly, owing to the constant repairs that were necessary, and since the tree after it is 1—2 feet in height is very hardy, the seedlings are kept in stockaded nurseries in the forest where planting operations are to take place and remain there until they are 10—12 feet high. They are then planted out in the forest. The nurseries must be kept free from long grass and under-growth which should be cut from time to time and heaped round the roots of the young plants in order to keep the soil moist and to serve as manure. Seedlings should not be transplanted into the stockaded forest nurseries until they are at least 1 foot high. Smaller plants generally die, unless they are watered, and this is not done in the forest nurseries.

(c) Planting in the forest.

Clearance of the lines.

25. Before planting out seedlings, lines are cleared through the forest, all trees and shrubs being cut level with the ground over a width of 20 feet. Any very large trees standing between the lines are felled at the same time, for if felled later on, they are liable to fall on and break the rubber plants. A path should also be made along the lines to facilitate inspection of the plants.

When the Charduar plantation was commenced lines 20 feet broad were cleared through the forest at distances of 100 feet apart and the plants were put out in the lines 50 feet apart. Interplanting was done in 1878-80 so that the plants were 25 feet apart. In 1892-93 the planting distance was changed to 70'×35' and again in 1901-02 to 66'×66' which gives ten plants to the acre. But it would seem preferable to plant the seedlings closer together in the lines, for when planted 66 feet apart, it requires some years before they grow together. It would perhaps be best to plant them 33 feet apart and to thin out when necessary. Cuttings might be planted alternately with the seedlings.

At first the lines were cleared due east and west, but of late they have been cleared due north and south. By the latter method the plants are shaded from the afternoon sun.

Mounds.

26. It has been found best to plant rubber seedlings on mounds, because the roots spread out near the surface of the ground. Seedlings planted in the ordinary way did not grow well. Stakes about 20 feet long and of a minimum diameter of 3 inches are set up in the lines at a distance of 66 feet apart and round each a mound 4 feet high is thrown up. The base of the mound is about 10 feet in diameter and it tapers to 4 feet diameter at the top.

Planting out.

27. Only seedlings over 10 feet in height are planted out in the forest at present. The roots are very large, so that they have to be cut off, leaving only 18 inches all round the plant. Some branches are also pruned off if necessary. In 1881-82 it was found necessary to prune off the lower branches and leaves from the trees, otherwise the deer were found to be induced by the taste of them to make desperate efforts to break the trees with their feet and horns to get at the top or crowns of them. The plants are carried to the forest and planted on mounds, care being taken to spread out the roots before they are covered with earth. To prevent animals pulling down the plants and the wind blowing them down, they are tied to stakes in at least two places, one being high up at 8 or 9 feet from the ground. The mounds should then be covered with grass and branches which when rotten act as manure. Rotten thatching grass is the best, as it does not ferment. It is impossible to put too much on and the more the better, but there should be at least 6 inches all over and 1 foot on the top. This operation should be repeated whenever the lines are cleared. It is money well spent as it doubles or trebles the rate of growth.

(d) Maintenance of the plantation.

Clearance of the lines.

28. Rubber plants require plenty of light. It is, consequently, absolutely necessary to keep them free from climbers and from being suppressed by the undergrowth which springs up with marvellous rapidity. If the lines are not cleared, the plants are soon smothered with climbers and killed. Formerly (in 1878-80) the lines were cleared three times a year, *viz.*, in May-June, August-September and November-December, but at present, owing to the scarcity of labour and the large quantity of work which has to be performed, this is only done once a year, after the rains. The climbers and the undergrowth should be cut so as to free the plants all round. There should be nothing in contact with the plants on any side. If any trees are standing above, or shading the plants too much, these trees should be felled, or at any rate some of their branches should be lopped off. But so long as the plants are freed all round, it appears an unnecessary expense to clear the lines to their full width between the plants at any rate every year. It should be sufficient to clear a path for purposes of inspection from one plant to the next.

Replanting vacancies.

29. All plants which have died should be replaced during the following rains. When the lines are being cleared, if any vacancies are found, the mounds and stakes should be prepared at once so as to be ready for planting when the rains set in. A note should be made of the numbers of the lines and of the number of vacancies requiring replanting in each. This will save much time, as it will be unnecessary to go over all the lines again and count the number of vacancies, as has generally been done.

Stakes.

30. Any stakes found to be rotten should be replaced when the lines are cleared if the plants are still small and liable to be broken down by deer or thrown down by the wind.

Mounds.

31. All grass and undergrowth cut when the lines are cleared should be piled on the mounds.

Felling trees between the lines.

32. When the rubber plants have reached some size they are liable to be suppressed by the trees left standing between the lines, which prevent their

lateral spread. As soon as this occurs these trees should be felled or girdled.

Rate of growth.

33. The measurements of 50 trees in each year's plantation (of 1874-75 to 1880-81) made during the years 1880-81 to 1897-98 are shown in Appendix I. They will give some idea of the rate of growth, which is very fast, of rubber trees in Charduar Plantation. The following measurements made in 1897-98 show the average height and girth of the trees in Kulsi Plantation :—

Plantation of	Average age.	Average height.	Average girth of central bole.
1873-77	22 years	88 feet	6⅓', largest 12¼'
1878	19 „	81 „	9'
1883	14 „	67 „	5'
1884	13 „	55 „	4⅓'

It will be seen that the girth is less, but the height greater than in Charduar Plantation. This is due to the trees being planted much closer together.

In 1899-1900 the girths and crowns of 10 per cent. of the trees tapped in Charduar Plantation were measured with the following results :—

Compartment.	Average age.	Number of trees measured.	Average girth.	Average maximum diameter of the crowns.
4	23 years	100	10·6'	64 feet
5	21 „	162	9·1'	61 „
6	21 „	95	7·4'	63 „
7	21 „	96	6·7'	61 „
8	21 „	77	6·2'	58 „

CHAPTER II.

ON THE TAPPING OF FICUS ELASTICA AND THE PREPARATION OF RUBBER FOR EXPORT.

Clearing the plantation lines.

34. Before the tapping operations commence all the undergrowth below the trees is cut level with the ground, so that bamboo mats can be spread to catch the latex which overflows from the cuts. A small path should also be cleared.

Clearing the trees of climbers.

35. At the same time all climbers which cover the trunks and branches of the trees must be cut so that they may be quite dead when the tappers come round.

Numbering the trees.

36. Each line of trees in each compartment should bear a number, the numbers starting from the principal road and the trees in each line should also be numbered serially. The following directions have been found necessary for the guidance of the officer in charge of the tapping operations. Every time the trees are tapped, the numbers should be painted over with coal tar; otherwise they soon disappear and no register of outturn from each tree could be kept up. Before starting the work the officer should walk along the block line at the end of the block and check the numbers on the last trees with the numbers in the register, *e.g.*, suppose the register shows 34 trees in a line, then the last tree should bear the number 34. When this has been done for all the lines, the officer should go again to the first line and see that each tree in the line bears its correct number. If there is any doubt, the register should again be consulted. When this has been done, the painting of the numbers can commence from tree number 1. When the first line has been done, the officer should walk back along the second line and check the trees as before, etc. It is essential that the old numbers on the trees should never be altered.

Fixing "pengs" to the trees.

37. The tapper before commencing to operate with the gouge is required to climb the tree he intends working and brush it down removing all dead twigs, climbers, leaves and other impurities which are likely to fall on the mats below, and at the same time every experienced tapper

affixes what are locally called "pengs," that is, pieces of green wood tied with split cane at right angles to the growth of the stem on all branches or boles which are difficult to hold on to when tapping, as both his hands must be free for the gouge and the mallet.

Tools used.

38. At present the cuts are made with a V-shaped gouge about 1¼ inches in greatest breadth. It is held in the left hand and a small wooden mallet in the right.

When tapping operations were started in 1898-99 "daos" and "khukries" or Assamese and Nepalese cutting knives were used, but this method resulted in inflicting gaping wounds which are still visible and it soon became evident that it was necessary for the future welfare of the plantation that some other implement should be employed. Experiments were then made with various other tools and of those the V-shaped gouge was found to be the best because the depth of the cuts made with this instrument can be to some extent regulated and the wounds also heal rapidly.

Method of tapping.

39. The tree being prepared the tapper climbs up to the highest branch it is intended to tap. He then gouges out the bark by giving horizontal cuts on alternate sides of the branch, taking care to remove only the bark without injury to the wood, but unfortunately this is not always done, the cambium layer is severed and the wound takes longer to heal. The interval between the cuts should be 15 inches, which is the length of the gouge, and each should extend more than half and less than two-thirds round the circumference of the branch or bole. No branch less than 2 feet in girth should be tapped.

Methods formerly employed.

40. In 1898-99, the year in which tapping operations were started, the system adopted was to make the cuts regularly one foot apart down the stem of the trees, these cuts being horizontal and not exceeding 8 inches in length and 2 inches in width. Aerial roots and branches less than a foot in girth were not tapped. It was afterwards found that no fixed rule can be laid down and that the experienced Nepalese tappers make the cuts 2 feet and often more apart and the length of the cuts varies with the girth of the bole. Again, they avoid making the cuts immediately one below the other and locate them alternately. The position of the cuts appears to have more effect on the yield than their number. In the

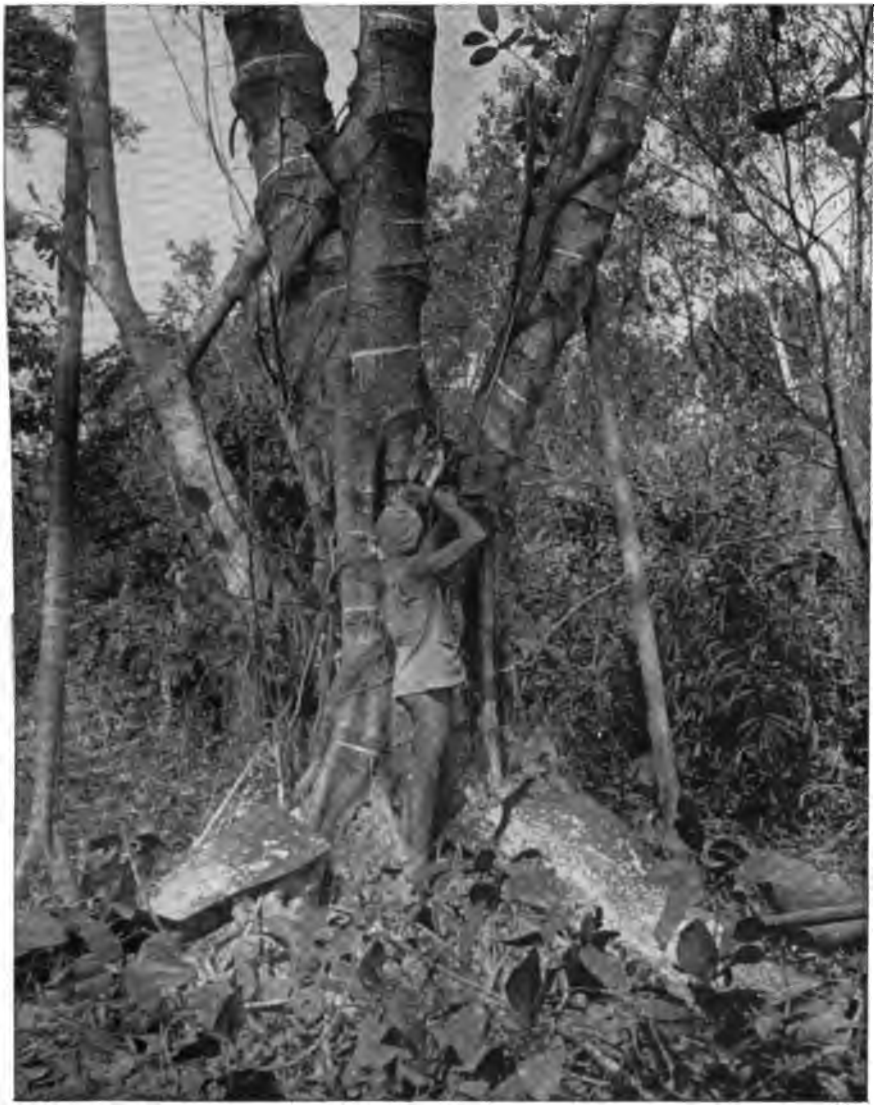

Photo -Mechl. Dept., Thomason College, Roorkee. E. M. Coventry, Photo

METHOD OF TAPPING.

following year further experiments were made. The cuts were made horizontal or only slightly oblique, it being noticed that the wounds bled in proportion to their horizontal direction and that any considerable deviation from this direction resulted in a slower and reduced flow of rubber. Experiments on untapped trees were made with the view of testing this point; arrow-shaped (the Brazilian method), oblique, as well as horizontal cuts being made, when it became apparent that the latex flowed far more freely from the last than from either of the others.

Occurrence of the latex.

41. The latex occurs in the bark and in the leaves. It seems safe to assert that the rubber cells are placed in more or less vertical rows when it will be readily understood why a horizontal cut must be much more effective in tapping their contents than a vertical or oblique cut of equal length.

Flow of the latex.

42. The latex exudes from the surfaces of the cut bark and some of it overflows and falls to the ground, but after two to three minutes the flow ceases and the remainder of the latex coagulates in the cuts. When dry it is stripped off the tree and when this is done a milky and sometimes copious residuum runs from the wound down the tree. It has been ascertained that this liquid contains no caoutchouc and is capable of being absorbed by blotting paper or of being evaporated in the sun; that, in fact, it consists of little else than water.

In March the latex becomes of a watery nature and a large proportion of it which spurts out of the wound and is collected on mats evaporates leaving no trace.

Collection of mat rubber.

43. Formerly the overflow was collected from the ground after it was dry and was called "ground rubber," but lately bamboo mats have been spread under the trees to catch this overflow. Ordinary bamboo mats 5′ × 2½′, which cost from 1 anna to 1½ annas each, are used for collecting the overflow of latex from the cuts. These mats are first well dried in the sun for a week, for if green bamboo mats are used the rubber becomes discoloured and black, and for this reason for the last two years a strong solution prepared by boiling down 1 part of rubber bark (cut into small strips) in 60 parts of water for 5 hours, is smeared over each mat before use in order that the mat rubber might obtain the same red

tint which the rubber derives from contact with the bark. As there has been little or no difference in the price of the coloured and uncoloured rubber, it is proposed to discontinue this practice and, instead, give every matman six well-dried mats, which he spreads out on the ground one by one, watching the drip of the latex from the cuts as they are being made.

The latex of the Ficus Elastica being very viscid only flows for about three minutes after the cut has been made: as soon as the drip from the cut ceases the mats are struck on the back with a stick to throw off strips of bark and other impurities which may have fallen from above and thus the same six mats may be used over and over again until they are thickly coated with coagulated latex. Any impurities seen imbedded in the latex are removed at once and the mats are then be put out in the sun, and when dry enough, (generally after two days), the rubber is pulled off and after picking and cleaning is weighed in at the godown and at once given out to women for further hand picking. At the close of each day's work all the mats in use are put in the sun for a short time to dry and are then carefully put away under shelter from the dew and rain. Each mat will ultimately carry a sheet of rubber from three to five pounds in weight, but as soon as the mats turn black they should be thrown away. Small tins and mats have been hung below the cuts to catch the latex, as an experiment, but the system has been abandoned as being too expensive.

Collection of tree rubber.

44. Generally on the third day after the cuts have been made (the time depending on the weather) the latex which has remained in the cuts is dry enough to be pulled off the tree. It should be kept in long strips and on no account be rolled up into balls for if the tappers are allowed to roll up the rubber, stones, bark and other impurities will be found inside the balls. As a tapping register is kept up showing the yield of each individual tree separately, the rubber after collection from the cuts has to be weighed at the foot of the tree and thereafter the whole of one day's collection is taken to the godown and re-weighed.

Cleaning the rubber.

45. Immediately after weighment it is given out to women to be hand-picked and cleaned. The longer rubber is left uncleaned the more difficult is it to work, as the impurities are held by the drying rubber and have

ultimately to be cut out. Tree rubber is divided into two classes "A" and "B" which are separated by the women when cleaning. Class A contains only the rubber which is collected from the cuts. Class B contains the rubber which runs from the cut down the branch or bole of the tree and not being coloured by the sap from the cut bark remains white or grey like the mat rubber.

The mat rubber is classed as "C" rubber.

Drying the rubber.

46. The three classes of rubber are kept separate in the godown spread out on shelves put up for the purpose. The sheets of mat rubber are hung up on cords stretched across the godown. Every morning, as soon as the fog lifts and the sun is bright, all the rubber is put out in the sun for a quarter of an hour and then replaced on the shelves.

Class A rubber should after drying in this manner for ten days be ready for packing, and the same applies to B rubber; but class C rubber is kept for a month before being packed.

Pressing the rubber.

47. When the rubber is quite dry 1 cwt. is weighed out and by means of screw pressure is converted into an 18-inch cube. After 24 hours it is ready for packing.

Packing the rubber.

48. The packing is done with country cotton cloth which by means of thorough washing has been deprived of all starch and other facing. After re-weighment the package is then sewn into a double gunny bag, the number and the weight of the rubber is stencilled on it and it is ready for export.

Season for tapping.

49. The best season for tapping is the cold weather from about the middle of October to the end of March. The yield is greatest from the middle of November to the middle of January, *i.e.*, when the growth of the trees is at the minimum. The colder the weather, the greater the outturn is said to be; but settled weather is essential, for if rain occurs within two days of tapping, part of the latex is washed away and the loss is heavy, while what remains on the stems loses in elasticity and becomes brittle and discoloured, and after some days of continuous rain it turns black in the same way as mat rubber, if washed, also turns black. Most rubber is yielded in the early morning. As the temperature rises the yield decreases and is at its lowest in the

evening. In cloudy weather the yield is said to be greater than when it is sunny.

Age of tapping.

50. The age at which the trees should be tapped is not exactly known, but it depends mainly on their size. It is known that the yield of small trees (say up to 3 or 4 feet in girth) is in the Assam plantations very small so that it hardly pays to tap them; but this may not be the case under other conditions than those obtaining at Charduar and Khulsi.

Interval between tappings.

51. It seems probable that rubber trees cannot be tapped every year without permanent injury but that they require at least one year's rest. Gamble ("Manual of Indian Timbers") states that "the tree will not bear yearly tapping, once in three years is as much as it will stand; if tapped yearly, it is liable to die off, as did many of the trees in Darjeeling after heavy tapping in 1871, 1872 and 1873. Those which then survived had not recovered sufficiently for retapping by 1880, and I have not heard of their having been tapped since then."

Twenty-one selected dominant trees in compartments 2 and 3 of Charduar plantation were tapped for three years in succession, *viz.*, 1896-97, 1897-98, and 1898-99 and yielded 46, 48 and 9 lbs. of rubber, showing a great falling off in the third year. Compartment 4 was also tapped for three years in succession, *viz.*, in 1898-99, 1899-1900 and 1900-01. In the third year only 100 trees were tapped, as there was a great falling off in the yield. Fifty trees were tapped by the method of opening the old cuts and 50 by making fresh incisions between the old cuts. The following figures show the result of tapping the 50 trees by the method of opening the old cuts:—

—	Yield in		
	1898-99	1899-1900	1900-01
	lbs. oz.	lbs. oz.	lbs. oz.
50 trees	55 7	42 4	14 8

These figures, as a whole, may be taken as conclusively proving that the tapping of trees three years in succession by the system of re-opening the old cuts is a failure. Under the system of retapping by making fresh incisions between the old cuts, the following figures show the total yield of the 50 trees so operated on for three years in succession:—

—	Yield in					
	1898-99		1899-1900		1900-01	
	lbs.	oz.	lbs.	oz.	lbs.	oz.
50 trees	43	0	35	13	24	1

There was a considerable falling off in the third year.

Trees have also been tapped twice during the same season, as an experiment, but at the second tapping the yield has been about 50 per cent. less than at the first.

Further experiments extending over some years are required before it can be known definitely at what intervals the trees should be tapped, but it seems probable that tapping cannot proceed every year, unless it is very lightly done. Part of Compartment No. 7, of Charduar plantation, has been tapped in 1905-06 after one year's rest and shows a large falling off in yield, whilst Compartment No. 1, of Kulsi plantation, tapped after an equal interval, shows a small increase. But the Deputy Ranger who has been in charge for three years considers the quality of rubber inferior to that previously obtained. Consequently it would appear that a rest for two years after tapping is required, but further experiments are necessary before any definite decision is arrived at.

Outturn of rubber, Charduar plantation.

52. The following figures show the outturn per acre and per tree in clean and dried rubber for the compartments tapped up to date at Charduar plantation:—

Compartment No.	Yield per acre in lbs. in							Yield per tree in lbs. in						
	1898-99.	1899-1900.	1900-01.	1901-02.	1902-03.	1903-04.	1904-05.	1898-99.	1899-1900.	1900-01.	1901-02.	1902-03.	1903-04.	1904-05.
1	8·6	...	...	27·7	...	...	30·9	0·5	...	...	1·6	...	...	1·8
2	9·0	...	...	34·4	...	...	35·9	0·5	...	...	1·9	...	...	2·0
3	11·3	...	...	30·5	...	...	36·9	0·7	...	...	1·9	...	...	1·8
4	9·7	9·1	6·1	...	22·6	...	...	0·6	0·6	0·4	...	1·4	...	...
5	...	9·2	...	...	20·4	...	...	...	0·6	...	...	1·4	...	...
6	...	11·5	...	...	22·4	...	...	...	0·8	...	...	1·5	...	...
7	...	10·4	...	...	...	23·6	...	...	0·8	...	...	...	1·8	...
8	...	8·9	...	...	...	25·2	...	...	0·7	...	...	...	1·9	...
9	...	...	8·0	...	...	15·8	...	...	...	0·7	...	...	1·5	...
10	...	...	11·2	...	...	...	25·0	...	...	0·9	...	...	...	2·1
11	...	...	6·4	...	...	...	17·5	...	...	0·4	...	...	...	1·2

It will be seen that there has been a large increase at the second tapping. The percentage of mat rubber in 1904-05 on the whole outturn was 26·8 per cent. The loss in cleaning and drying amounts to 3½ per cent., that of tree rubber being 3 per cent. and that of mat rubber 5 per cent.

The largest yield from a single tree in 1905-06 was 7 lbs. 15 oz.

In the report for 1874-75 it is stated that, if tapping is commenced in the branches, most rubber will be obtained from them; if in stem, from the stem. This requires proof. The branches are said to yield more rubber than the stem. In 1899-1900 and the previous year, the crowns of 10 per cent. of the trees tapped were measured, and it was found that the outturn of rubber was in proportion to the spread of the trees, those with the largest crowns yielding most.

Outturn of rubber, Kulsi plantation.

53. The Kulsi plantation, started in 1873, has an area of 153·6 acres. It has been divided into two blocks. Block A, area 80 acres, consisting of compartments 1 to 4, had an average age of 32 years in 1905-06 and

Block B, the remainder of the plantation, area 65·6 acres, of 28 years. The trees were first planted 100′ × 25′ apart. A few years later the spacing was altered to 50′ × 25′ and finally it was decided to plant 25′ × 25′. The yield of rubber is given below:—

Block or Compartment.	Planting distance.	Yield per acre in lbs.						Yield per tree in lbs.					
		1900-01.	1901-02.	1902-03.	1903-04.	1904-05.	1905-06.	1900-01.	1901-02.	1902-03.	1903-04.	1904-05.	1905-06.
C 1	50×25	27·1	...	...	44·1	...	48·06	1·1	...	...	1·6	...	1·8
C 2	50×25	28·0	...	...	44·2	..	...	1·1	...	...	1·7	...	...
C 3	50×25	29·0	...	...	45·0	...	..	1·0	...	...	1·6	...	...
C 4	50×25	29·4	...	...	42·2	...	...	1·1	...	...	1·5	...	...
Plantation 1878	50×25	...	57·4	...	...	61·0	...	...	...	...	...	2·3	...
„ 1883 Block I.	25×25	...	21·8	...	...	30·9	...	...	...	...	...	1·1	...
Plantation 1883 Block II.	25×25	...	30·1	...	...	30·4	...	...	...	...	...	0·5	...
Plantation 1883 Block III.	25×25	...	47·0	...	...	57·8	...	...	...	...	...	0·6	...
Plantation 1884	25×25	...	21·8	...	...	31·9	...	...	...	...	...	0·5	...

Analysis of rubber.

54. A sample of Charduar plantation rubber was analysed by the Reporter on Economic Products and gave the following results:—

—	Calculated on material as received per cent.	Calculated on material dried at 1000 C. per cent.
Caoutchouc (tree rubber)	76·67	77·47
Resin	19·2	19·3
Albuminoid matter	1·5	1·5
Dirt and insoluble matter	1·7	1·7
Moisture	0·9	...
Ash included in dirt	0·5	0·5

It was noted that the rubber contained comparatively small quantities of albuminoid matter, dirt and moisture and that so far as these constituents are concerned no objection can be taken to its quality. The amount of resin present is abnormally high, the quantity of this material usually found is the rubber of Ficus elastica being from 3 to 7 per cent. This high percentage appears to be a constant feature of rubber produced in the Charduar plantation, a sample previously examined at the Imperial Institute having been found to contain 18 per cent. No precise data are available to show how the composition of the rubber of Ficus elastica varies with the age of the trees from which it is obtained, and it would probably be of interest to examine samples of Charduar rubber from time to time in the future in order to determine whether the amount of rubber decreases as the trees mature or whether it is independent of age and due possibly to climate or other external causes inducing a change in the composition from that obtained from the branches.

Analysis of bark and leaves.

55. Twenty-five lbs. each of bark and leaves were collected and after drying in the sun for three days the samples were forwarded to the Imperial Institute for analysis with the following result.

Bark.—" The bark was in the form of narrow strips, about one inch wide, which had evidently been obtained in tapping operations. On breaking these strips there was little evidence of the presence of rubber in the bark, as only in a few cases were any threads of caoutchouc visible.

The rubber present in the bark was estimated by extracting with hot chloroform and precipitating the concentrated solution by the addition of alcohol. In this way 0·7 per cent. of caoutchouc-like material was obtained from the bark, but it is of very poor quality as it possessed little elasticity or tenacity and hardened on standing.

Leaves.—" The leaves were quite dry and brittle, and when treated in the same manner as the bark no caoutchouc or caoutchouc-like material could be extracted from them."

It is noted that better results might have been obtained by working with fresh material and that it would have been better to have dried the specimens in the shade than in direct sun light. Also that the latex present in the leaves of rubber trees is often of a very resinous nature and the product might be of very little commercial value.

Cost of tapping operations.

56. In 1904-05 the cost of tapping operations at Charduar amounted to Re. 0-6-10 per pound of clean, dry rubber. The cost includes that of clearing the rubber lines, purchase of mats, cloth, gunny bags and gouges, erection of temporary huts, tapping, cleaning, drying, packing, cartage to Tezpur, colouring the mats and making of wooden presses, etc. The rubber was sold for Rs. 2-11-0 per lb. delivered at Tezpur.

Coal-tarring the cuts.

57. When operations were started in 1898-99 the cuts were coal-tarred. This was found unnecessary and has been discontinued. The cuts, especially those made with the V-shaped gouge, heal rapidly.

Measurements of girth and crowns of the trees.

58. During the first three years the crown and girth measurements of 10 per cent. of the trees were taken, sal pegs being driven into the ground to mark the crown measurements and a coal-tarring to show where the girth ot the trees had been taken. These measurements besides being entered in a book were struck on to a large zinc label which was affixed to the trees. The report of 1899-1900 states that the girth measurements of the trees are difficult to make in a uniform manner, owing to aerial roots which form supplementary stems having a tendency to anastomose so that the figures under this head may be ignored : and the report of the following year that after considering the question of these crown measurements on the ground it was decided that in no single instance would any two persons agree in the measurements taken. It may, however, be accepted as an axiom that the greater the leaf canopy, the larger the root system and the greater the yield of the tree. After this year the measurements were discontinued.

Root tapping.

59. The practice of tapping the roots of rubber trees is often carried on illicitly in the forests. It is most destructive and often kills the trees. It might be prevented by imposing a very high duty on root rubber which can be easily distinguished from the rubber obtained from other parts of the tree. This proposal is at present under consideration.

Labour employed.

60. At first "mikirs," who are said to be the best tappers in Assam, were employed on a daily wage of eight annas per day. Nepalese and local Assamese were also engaged and paid Rs. 30 and Rs. 20, respectively, per maund of rubber collected. At present Garos and local Assamese are employed. They are paid annas four per pound of rubber collected. It is necessary that the men should be good climbers, since they have to use both hands when tapping the trees. Each tapper is accompanied by a boy, his son or some near relative, so that both tappers and matman have the same interest in the cleanliness of the mat rubber. One matman is able to move the mats of two tappers who are working at the same tree, but one matman cannot attend to two men who are tapping different trees.

NOTE BY S. EARDLEY-WILMOT, INSPECTOR-GENERAL OF FORESTS.

THE information embodied in this pamphlet comprises what has been learnt in Assam regarding the plantation of Ficus elastica there, but the financial statistics of these plantations would form no guide to the planter who commences operations with 30 years of departmental experience to guide him, and they have therefore been omitted.

2. It may, however, be stated that it would cost about Rs. 20 per acre to stock that area with rubber trees whether large seedlings are put out at from 16 to 20 to the acre or a greater number of smaller transplants. The cost of preparing the plantation for the reception of the plants would vary with the locality; where virgin forest or swampy ground has to be dealt with the expenditure would naturally be higher than if neither of these drawbacks were present, involving expensive clearances or the construction of mounds. In any case the maximum cost of preparation should not be more than Rs. 20 or Rs. 30 per acre, bringing up the total to Rs. 40 or Rs. 50 per acre stocked with young plants.

3. It appears to me personally that where damage from wild animals is not to be anticipated it might be preferable to put out younger plants about 30 to 50 to the acre, so that probably after a very few years these would by their shade keep the undergrowth in check and future expensive cleanings would be unnecessary. It also seems to me that the tapping of such a fully stocked plantation could be commenced much earlier than at 25 years of age, probably at 12 or 14 years; the yield would not be large per tree but would amount to a considerable weight per acre although the cost of collection would probably run rather high.

4. The question of the greatest yield per acre, based on the number of trees on that area, must be made the subject of careful enquiry, for it is obvious that a point must be reached when the yield from a large number of smaller trees would be equal or more than that from a few larger stems. Meanwhile all we know is that at 20 to 25 years of age an acre of plantation containing 16 to 20 trees will yield about 35 lbs. of rubber every third year; and that there is every reason to surmise that

in the previous five to ten years it might have yielded one-third that amount and would in the following ten years give a larger quantity. Whether this increase will continue for many further terms of ten years and whether the planter should, to obtain this advantage, maintain or reduce the number of standards per acre is unknown.

5. The yield of the Assam plantations is extremely small; we read that in Java on a plantation of 72 acres, on which were planted 5,200 trees, tapping commenced at 14 years of age and that after 7 years work the outturn per acre per annum was 71 lbs. of rubber. At Charduar the outturn of 23 to 25 years old trees is about one-sixth of that amount, and this justifies further enquiry as to the method and recurrence of tapping operations. It appears probable that if the latex could be collected without subjecting the tree to such extensive bark injuries the outturn could be very largely increased. It is possible that the vitality of the tree suffers from the removal of such a large percentage (about 4 per cent.) of its bark during each tapping operation and that this, and not so much the flow of latex, renders yearly tapping impossible. This is a subject on which more knowledge is required.

6. The rubber of Assam contains so large a proportion of resin (19 per cent.) that its commercial value is considerably diminished. It may be sold, as during the current year, at the railway, four miles away, at Rs. 3 per pound on the total outturn of good, bad and indifferent, but this leaves a wide margin on the 6*s*. per pound given in London for fine Para biscuits. We require some further knowledge of the demands of the tree in soil, climate and locality and their influences, if any, on the proportion of resin in the latex and on the outturn of rubber; and as the finest natural rubber trees are found on the well drained slopes of the sub-tropical hills we may have doubts whether the production of the best rubber is feasible in localities which for weeks of the year are either covered with water or are subject to repeated inundations of a less permanent nature as is the case at Charduar and Khulsi.

7. Finally the cost of collection might probably be reduced, and as this now amounts to 4½ annas per pound in the plantations, where there is no undergrowth, to 7 annas per pound in other localities less favourably situated, this subject will also doubtless repay further investigation. In this regard the comparative cost of tapping many smaller or a few larger trees will have to be considered, the physical labour and danger being greater in the latter case.

APPENDIX I.

Height growth in feet.

	CHARDUAR PLANTATION.								Bamoni Hill plantation
Age in years.	Plantation of							Average.	
	1874-5.	1875-6.	1876-7.	1877-8.	1878-9.	1879-80.	1880-1.		of 1874-5.
1							7·36*	7·36	
2						10·17	9·80	9·98	
3					16·36	12·50	13·66	14·17	
4				21·07	19·0	17·41	15·69	18·29	
5			24·69	24·58	23·31	19·85	20·08	22·50	
6		26·87	28·50	29·41	25·41	23·91	24·58	26·45	
7	31·26	29·25	32·25	30·27	30·16	29·75	28·66	30·23	
8	32·75	34·41	34·17	34·75	33·83	34·83	32·0	33·82	
9	37·66	36·36	38·16	40·75	37·58	38·25	38·58	38·19	
10	40·06	40·08	46·83	44·83	42·16	44·0	43·33	43·04	
11	43·33	44·58	47·91	48·50	46·16	48·41	46·83	46·53	
12	49·0	49·83	52·25	53·75	49·41	52·08	47·83	50·59	36·5
13	53·25	52·33	55·83	57·0	52·25	53·08	50·16	53·41	40·58
14	55·83	57·50	61·16	60·75	53·25	54·16	55·75	56·91	42·91
15	61·91	61·41	63·83	61·75	55·41	60·75	59·91	60·71	47·25
16	64·33	64·75	64·91	64·08	59·75	63·25	64·08	63·59	55·41
17	66·75	65·83	67·66	68·83	63·16	66·41	65·33	66·28	58·83
18	67·91	68·91	71·66	72·16	65·08	67·41	68·0	68·73	60·75
19	71·08	73·08	75·08	73·41	69·16	70·83		72·11	62·91
20	74·75	76·0	77·66	74·91	71·58			74·98	69·66
21	77·33	77·58	80·41	78·41				78·43	73·66
22	78·0	81·58	80·91					80·16	77·08
23	83·25	83·66						83·45	80·50
24	85·0							85·0	84·16

* These must have been three or four years old when planted out.

Average annual increase in height for Charduar plantation

$$\frac{85 - 7{\cdot}36}{23} = 3'{\cdot}38.$$

Bamoni Hill plantation

$$\frac{84{\cdot}16 - 36{\cdot}5}{12} - 4'{\cdot}01.$$

APPENDIX II.

Circumference growth in feet.

Age in years.	CHARDUAR PLANTATION. Plantation of 1874-5.	1875-6.	1876-7.	1877-8.	1878-9.	1879-80.	1880-1.	Average.	Bamoni Hill plantation of 1874-5.
1							0·26	0·26	
2						0·35	0·42	0·38	
3					0·67	0·58	0·66	0·64	
4				0·99	1·0	0·83	0·98	0·95	
5			1·26	1·58	1·08	1·20	1·83	1·39	
6		1·28	2·0	1·75	1·55	2·41	1·91	1·82	
7	1·76	2·08	2·08	2·19	2·41	3·33	2·58	2·35	
8	2·66	2·08	2·38	3·75	3·33	3·83	3·50	3·05	
9	2·66	2·84	4·75	3·91	3·41	3·91	4·16	3·66	
10	3·55	4·58	4·91	4·25	4·08	5·16	4·83	4·48	
11	5·41	6·25	5·0	5·33	4·50	5·66	4·83	5·28	
12	8·91	6·78	6·91	5·91	5·75	6·58	5·50	6·52	
13	9·0	7·33	7·41	6·66	6·91	6·66	5·58	7·08	
14	10·66	7·83	8·16	7·915	7·0	6·75	6·25	7·77	
15	11·41	9·16	9·08	7·83	7·16	7·58	7·41	8·52	10·83
16	12·16	9·83	9·16	7·91	8·0	7·75	8·91	9·10	12·41
17	13·66	10·0	9·25	8·16	8·25	10·66	11·41	10·20	13·29
18	13·83	10·08	11·0	8·50	8·91	12·33	12·16	10·97	14·16
19	13·91	11·08	12·0	11·08	11·16	13·25		12·08	14·33
20	15·75	12·41	12·16	12·83	11·50			12·93	15·58
21	16·75	14·91	14·08	13·75				14·87	15·91
22	18·0	16·16	14·91					16·36	16·0
23	18·91	20·75						19·83	16·25
24	23·16							23·16	16·91

Average annual increase in girth

$$\frac{23·16 - 0·26}{23} = 0·99 \text{ feet for Charduar plantation.}$$

$$\frac{16·91 - 10·83}{9} = 0·68 \text{ feet for Bamoni Hill plantation.}$$

The measurements were apparently made over the aerial roots.

APPENDIX III.

Areas, etc.

Compartment.	Area in acres.	Number of lines.	Number of trees.	Years in which opened.	Year in which planted.	Year in which replanted.	REMARKS.
1	66·07	29	1,108	1873-4	1873-4 1878-9		In 1879-80 trees interplanted so as to be 25′ apart.
2	73·48	36	1,209	Do.	1873-4 1878-9		
3	79·80	42	1,225	1874-5	1875-6		Do.
4	94·31	43	1,521	1874-5	1875-6		D o.
5	126·84	41	1,859	1876-7	1876-8		
6	77·25	40	1,112	Do.	1876-8		Do.
7	80·39	38	1,062	Do. & 77-8	1876-9		Do.
8	73·73	37	978	Do. & 77-8	1876-9		
9	87·80	30	946	1878-9	1881-2		
10	76·30	29	772	Do.	Do.		
11	94·9	30	1,413	1882-3	1882-3		Seedlings were planted on forks of trees over 30 acres in 1883-5.
12*a*	98·30	20	943	1888-9	1888-9	1892-3	
12*b*	(61)	18		1897-8 1895-6	1897-8 1895-6		
12*c*	50	10	494	1903-5	1903-5		
13	29·59	24	The plants have not been counted lately.	1884-5	1884-5		
14	65·43	16		Do.	Do.		
15	115·0	56		1884-5 1888-9	1884-5 1890-1	1892-3	
16	299·0	91		1889-90	1890-1	1892-3	
17	102	36		1890-1	1890-1 1891-2	1892-3	
18	407·4	116		1891-2 1892-7	1892-7		
19	262·5	92		1899-1900	1899-1900		
20	364·7	76		1900-1	1900-1 & 01-02		
21	23·06	2½		Do.	Do.		
Total .	2747·85						

APPPENDIX IV.

Area statement.

Year.	Compartments opened or planted.	Areas added.	Other alterations in area.	Area at close of year in acres.
1873-4 . . .	1 and 2	180	...	180
1874-5 . . .	...	...	...	180
1875-6 . . .	3 and 4	140	...	320
1876-7 . . .	5 (part or whole), 6 (part), 7 (part)	110	...	430
1877-8 . . .	5 (part), 6, 7 and 8 (parts)	143	...	573
1878-9 . . .	1 (part), 2 (part), 7 (part), 8 (part)	112	...	685
1879-80. . .	9 and 10	118	...	803
1880-1 . . .	...	...	...	803
1881-2 . . .	...	...	...	803
1882-3 . . .	11	89	...	892
1883-4 . . .	Seedlings ~~received~~ planted in forks of trees in compartment 12.	...	...	892
1884-5 . . .	13 and 14	120	...	1,012
1885-6 . . .	15 (part) or 14 (part)*	31	...	1,043
1886-7 . . .	...	...	...	1,043
1887-8 . . .	...	...	...	1,043
1888-9 . . .	12 *a* and 15 (part)	63	...	1,106
1889-90 . .	15 (part) and 16	432	...	1,538
1890-1 . . .	17	225	...	1,763
1891-2 . . .	...	...	...	1,763
1892-3 . . .	18	300	...	2,063
1893-4 . . .	18	41	...	2,104
1894-5 . . .	...	...	...	2,104
1895-6 . . .	12*b*	20	41*c*	2,165
1896-7 . . .	18	12	— 518*a*	1,659
1897-8 . . .	12*b*	41	...	1,700
1898-9 . . .	Potasali block	40	...	1,740
1899-1900 . .	19	180	+ 278*b* + 98*c*	2,296
1900-1 . . .	20	80	+ 193*c*	2,569
1901-2 . . .	20	271	...	2,840
1902-3 . . .	21	13	...	2,853
1903-4 . . .	12*c*	10	— 40*d*	2,823
1904-5 . . .	12*c*	40	— 117*a*	2,746

a = disforested.

b = reafforested.

c = corrections of area.

d = Postasali block abandoned.

* *c*14 according to the annual report, but the area of *c*13 and 14 is only 95 acres and 120 acres were planted last year.

APPEN

Statement showing the outturn of Rubber

Compartment.	Area in acres.	Area tapped.	Year.	Number of trees tapped.	OUTTURN					
					TREE RUBBER.			MAT RUBBER.		
					Gross.	Nett.	P. c. of loss in cleaning.	Gross.	Nett.	P. c. of loss in cleaning.
1	66·1	66·1	1898-99.	1,149	...	...	...	...	...	...
		66·1	1901-02.	1,133	1,250	...	...	635	...	...
		66·1	1904-05.	1,107	1,616	1,565	3	501	476	5
2	67·7	67·7	1898-99	1,174	...	...	...	...	...	...
		67·7	1901-02.	1,228	1,549	...	...	830	...	...
		67·7	1904-05.	1,220	1,790	1,735	3	737	697	5
3	75·3	75·3	1898-99.	1,212	...	...	...	...	...	...
		75·3	1901-02	1,216	1,553	...	...	806	...	...
		57·6	1904-05.	930	1,314	1,271	3	373	358	4
4	94·3	94·3	1898-99.	1,514	...	...	...	...	...	...
		94·3	1899-1900	1,499	...	...	...	...	...	...
		...	1900-01	100	...	...	...	...	...	...
		94·3	1902-03	1,488	1,487	1,464	1½	692	672	3
5	126·8	126·8	1899-1900	1,849	...	...	...	...	...	...
		126·8	1902-03.	1,866	2,093	2,068	1	544	524	3½
6	77·25	77·25	1899-00.	1,116	...	...	...	...	...	...
		77·25	1902-03	1,112	1,428	1,411	1	340	323	5
7	80·39	80·39	1899-1900	1,060	...	...	...	...	...	...
		80·39	1903-04.	1,062	1,436	1,377	4	541	522	3½
		...	1903-04. Do. 2nd tapping.	52	37	35	5	9	8	11
8	73·73	73·73	1899-1900	980	...	...	...	...	...	...
		73·73	1903-04	978	1,443	1,407	2½	470	447	5
		...	1903-04. Do. 2nd tapping.	50	30	28	6½	8	8	...
9	87·8	87·8	1900-01.	953	...	...	...	...	...	..
		87·8	1903-04.	946	1,116	1,082	3	318	307	3½
		...	1903-04 Do. 2nd tapping.	50	26	25	4	8	8	...
10	66·9	66·9	1900-01.	808	681	...	...	67	...	...
		66·9	1904-05.	772	1,172	1,131	3½	505	483	4
11	94·9	94·9	1900-01	1,495	555	...	...	49	...	...
		94·9	1904-05.	1,413	1,171	1,135	3	555	522	6
2 Nursery.	5·8	5·8	1901-02.	756	...	...	...	..	...	...
		5·8	1904-05.	?	{ 50	47	...	16	16	...
		5·8	1904-05. Do. 2nd tapping.	?	{ 27	27	...	10	9	...
		...	...	...	77	74	4	26	25	4
3 Nursery.	4·5	4·5	1901-02.	315	...	...	...	...	...	...
		4·5	1904-05.	?	114	110	3½	40	38	5
10 Nursery.	9·4	9·4	1904-05.	?	129	124	4	28	26	7

DIX V.

from the Charduar Rubber Plantation.

IN POUNDS.

TOTAL.			PER ACRE.						PER TREE.					
			Tree rubber.		Mat rubber.		Total.		Tree rubber.		Mat rubber.		Total.	
Gross.	Nett.	P. c. of loss in cleaning.	Gross.	Nett.	Gross.	Nett.	Gross.	Nett.	Gross.	Nett.	Gross.	Nett.	Gross.	Nett.
611	576	5½	...	...	...	...	9·2	8·6	...	...	...	...	0·5	0·5
1,885	1,836	2½	18·9	...	9·6	...	28·5	27·7	1·1	...	0·6	...	1·7	1·6
2,117	2,041	3½	24·4	23·7	7·6	7·2	32	30·9	1·5	1·4	0·4	0·4	1·9	1·8
655	607	7	...	...	...	...	9·7	9·0	...	...	...	...	0·6	0·5
2,379	2,328	2	22·9	...	12·3	...	35·2	34·4	1·3	...	0·7	...	2·0	1·9
2,527	2,432	4	26·4	25·6	10·9	10·3	37·3	35·9	1·5	1·4	0·6	0·6	2·1	2·0
902	848	6	...	...	...	...	12·0	11·3	...	...	...	...	0·7	0·7
2,359	2,295	3	20·6	...	10·7	...	31·3	30·5	1·3	...	0·7	...	2·0	1·9
1,687	1,629	3	22·8	22·1	6·5	6·2	29·3	28·3	1·4	1·4	0·4	0·4	1·8	1·8
1,042	916	12	...	...	...	...	10·1	9·7	...	...	...	...	0·7	0·6
912	863	5½	...	...	...	...	9·7	9·1	...	...	...	...	0·6	0·6
...	39	...	...	...	...	...	...	6·1	...	...	...	...	...	0·4
2,179	2,136	2	15·8	15·5	7·3	7·1	23·1	22·6	1·0	1·0	0·5	0·4	1·5	1·4
1,243	1,176	5½	..	...	...	...	9·8	9·3	...	...	...	...	0·7	0·6
2,637	2,592	1½	16·5	16·3	4·3	4·1	20·8	20·4	1·1	1·1	0·3	0·3	1·4	1·4
940	889	5½	...	..	...	...	12·3	11·5	...	...	...	...	0·8	0·8
1,768	1,734	2	18·5	18·3	4·4	4·2	22·9	22·5	1·3	1·3	0·3	0·3	1·6	1·6
882	833	5½	...	...	...	...	11·0	10·4	...	...	...	...	0·8	0·8
1,977	1,899	4	17·9	17·1	6·7	6·5	24·6	23·6	1·4	1·3	0·5	0·5	1·9	1·8
46	43	...	...	...	...	...	...	...	0·7	0·7	0·2	0·1	0·9	0·8
694	657	5	...	...	...	...	9·4	8·9	...	..	...	...	0·7	0·7
1,913	1,854	3	19·6	19·1	6·4	6·1	26·0	25·2	1·5	1·4	0·5	0·5	2·0	1·9
38	36	5	...	...	...	...	...	...	0·6	~~0·6~~ 0.5	0·2	0·2	0·8	0·7
...	749	...	...	...	...	...	...	8·5	...	...	...	...	...	0·8
1,434	1,389	3	12·7	12·3	3·6	3·5	16·3	15·8	1·2	1·2	0·3	0·3	1·5	1·5
34	33	3	...	...	...	...	...	...	0·5	0·5	0·2	0·2	0·7	0·7
748	...	...	10·2	...	1·0	...	11·2	...	0·8	...	0·1	...	0·9	...
1,677	1,614	4	17·5	16·9	7·5	7·2	25·0	24·1	1·5	1·5	0·7	0·6	2·2	2·1
604	..	...	5·9	...	0·5	..	6·4	...	0·4	...	...	...	0·4	...
1,726	1,657	4	12·3	12·0	5·9	5·5	18·2	17·5	0·8	0·8	0·4	0·4	1·2	1·2
80	79	1	...	...	...	...	13·8	13·6	...	...	...	...	0·1	0·1
66	63	...	..	..	...	...	..	...	...	...	...	...	...	...
37	36	...	...	...	...	...	...	...	...	...	...	...	...	...
103	99	4	13·3	12·7	4·5	4·3	17·8	17·0	0·1	0·1	...	...	0·1	0·1
20	20	...	...	...	...	...	4·4	4·4	...	...	...	...	...	...
154	148	4	25·3	24·5	8·9	8·4	34·2	32·9	0·4	0·4	0·1	0·1	0·5	0·5
157	150	4	13·7	13·2	3·0	2·8	16·7	16·0	...	...	...	...	...	...

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NOTES

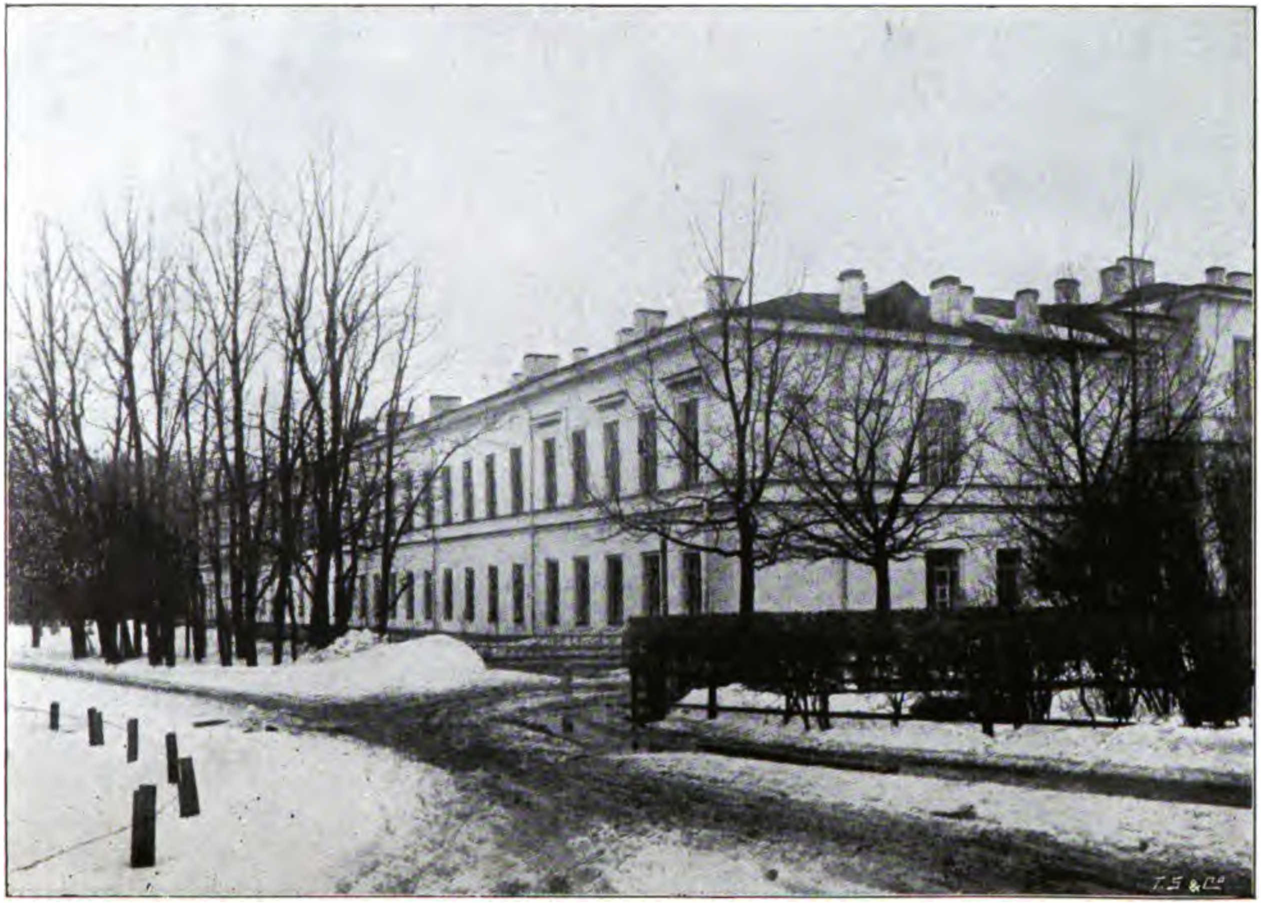
ON

A VISIT TO SOME EUROPEAN SCHOOLS OF FORESTRY.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.

CALCUTTA:
OFFICE OF THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.
1906.



The Imperial Institute of Forestry St. Petersburg, Russia.

Frontispiece.

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NOTES

ON

A VISIT TO SOME EUROPEAN SCHOOLS OF FORESTRY.

PART I.

INTRODUCTORY.

THE following notes were drawn up during a series of visits paid to some of the chief Continental Schools of Forestry between April and June 1904. The places visited comprised the Academies of Eberswalde in Prussia, Tharandt in Saxony, Aschaffenburg in Bavaria, the University at Munich, also in Bavaria; the Imperial Forest Institute at St. Petersburg, the Forestry and Agricultural College at Vienna and the Nancy Forest School in France. On the completion of the tour that part of the R. I. E. College, Cooper's Hill, more especially devoted to the instruction of the Forest Students was also visited in order that the relative value of the Continental and English methods might be compared.

The primary object kept in view in visiting these Forest institutions was the study of the zoological collections and the methods of tuition in that subject. It was also found possible, however, owing to the extreme courtesy shown by the various Directors in charge of, and Professors attached to the colleges, to study the whole arrangements of the various institutions visited, thus obtaining a fair idea as to the most up-to-date lines upon which the best forest schools of the Continent are now carried on. The visits were paid in every case, with the exception of France (where, in addition, an opportunity was afforded of accompanying the Senior Students on a tour) in the lecture term and thus the advantage was gained of visiting the various branches of the colleges in company with the Professors. In order to render the notes more intelligible plans are given depicting the arrangement of rooms, cases and objects of interest in use in the Forest.

The tour extended to Brussels, Berlin, Eberswalde, St. Petersburg, Dresden, Tharandt, Aschaffenburg, Munich, Vienna, Genoa, Nancy, and Paris and occupied about nine weeks.

Where possible visits were paid to the forests in the neighbourhood of the colleges—forests which were often instruction forests worked solely under the orders of the Director and for the benefit of the students—and observations were made upon various devices for guarding against or counteracting the attacks of injurious insects and, in fact, of animals of all kinds.

PART II.

THE FOREST INSTITUTIONS, ETC., VISITED.

Seven of these institutions were visited, four in Germany, one in Russia, one in Vienna and one in France. Examination showed that most of these establishments were, broadly speaking, managed upon the same general scheme of instruction, whilst the arrangement of the building or buildings themselves was in conformity, as far as had been possible with the funds allowed by the State for erection and maintenance. It will not therefore be necessary to describe separately and in full detail each institution visited since this would involve a considerable amount of unnecessary repetition.

Taking the German Universities first, it is therefore proposed to fully describe the Forestry buildings at the University of Munich, which a concensus of opinion places in the first rank of German Forest Instructional Institutions, subsequently considering any minor differences or improvements existing at the other German Academies; the colleges at St. Petersburg, Vienna and Nancy will be treated in the same way.

1. THE GERMAN ACADEMIES.

a. The Forestry College at Munich University, Bavaria.

This college forms a part of the University of the town and State and considerable sums of money have only quite recently been expended upon it with the object of bringing it thoroughly up to date. The buildings devoted to forestry instruction are two in number, both situated in the grounds of the University. There is a fine staff of some ten professors, their numbers including three such well-known men as Professors Rauley, Myer and Tubœuf, each eminent authorities in their own branches of study. The lectures given in this institution are open to any University undergraduate. The college is to a certain extent affiliated with that at Aschaffenburg, the Bavarian forest students taking the first two years of their course at that Academy, and thence proceeding to Munich for the remaining two years. In consequence some subjects are entirely taught at Aschaffenburg, whilst others are only touched uponor not taken up at all until the University is reached. The various courses of lectures are delivered by men who are specialists in the subjects upon which they lecture, the whole of their spare time being devoted to further study in their own branches of science both in the forest and laboratory; the results of their observations and investigations are thus of direct benefit to their State.

The Forest Buildings.—These are two in number, the old building and the new, situated within a few yards of one another. The old building contains the zoological suite of rooms on the second floor, the first floor and the basement being devoted to Botany. The new building was only opened four years ago. It contains the chemical, mineralogical, meteorological laboratories, etc., in the basement; forest surveying, mathematics and wood museums, etc., on the first floor and forest instruments, forest products, etc., on the third floor.

Each of the suites contains as far as possible and where necessary a lecture hall, museum (of one or more rooms), laboratories, professor's working room and private laboratory, assistant's room, packer's and apparatus room and dark room for photography.

THE OLD BUILDING.

Zoological museums, laboratories and lecture hall.

Although even in the Munich College the space devoted to Zoology is a little short of the actual requirements the plan in fig. 1 shows that it is possible, with the rooms allotted, to provide both work room and exhibition galleries.

Professor Dr. Pauley takes the zoological course and the building up of the fine forest zoological collections, which may be regarded as second to none in Europe, and the lines upon which the lectures are delivered, are solely due to his own initiative. Dr. Pauley's writings and investigations into questions relating to forest zoology and forest pests are well known and an examination of his museums and method of delivering his lectures will show that but little improvement is possible. The museums are so arranged as to put before the students in the most practical and efficient manner the damage done in the forest by animal pests of all kinds. For example, there is a most wonderful series of barks and woods illustrating the biology of *Scolytidæ*. Dr. Pauley has done a great deal towards the study of the European forms of this group, so important a one to the Forester. As evidence is daily increasing as to the destructive powers of the Indian forms of this family an examination of Dr. Pauley's collections and arrangements was of great advantage,

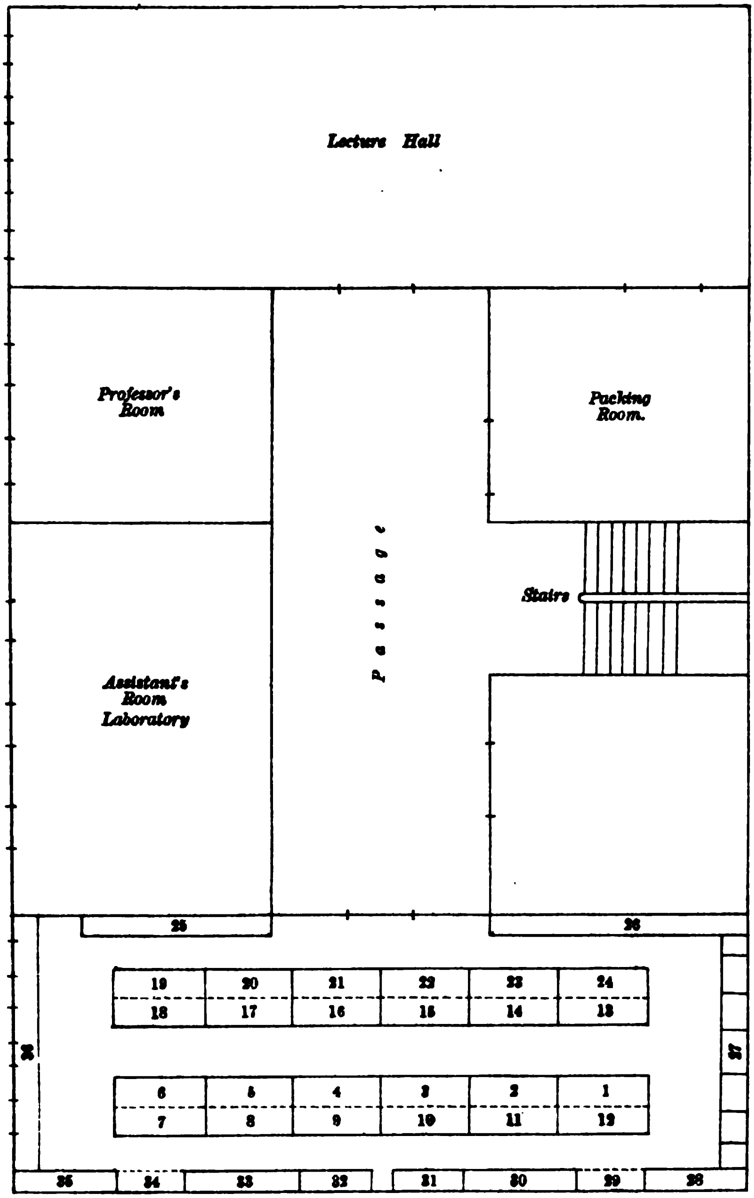

Fig. 1

Fig. 1. Plan of suite of rooms devoted to Zoology, Munich Museum.

(to face page 4)

ho.-Mechl. and Litho. Dept., Thomason College, Roorkee. Zinco., February, 1906.—No. 1425-

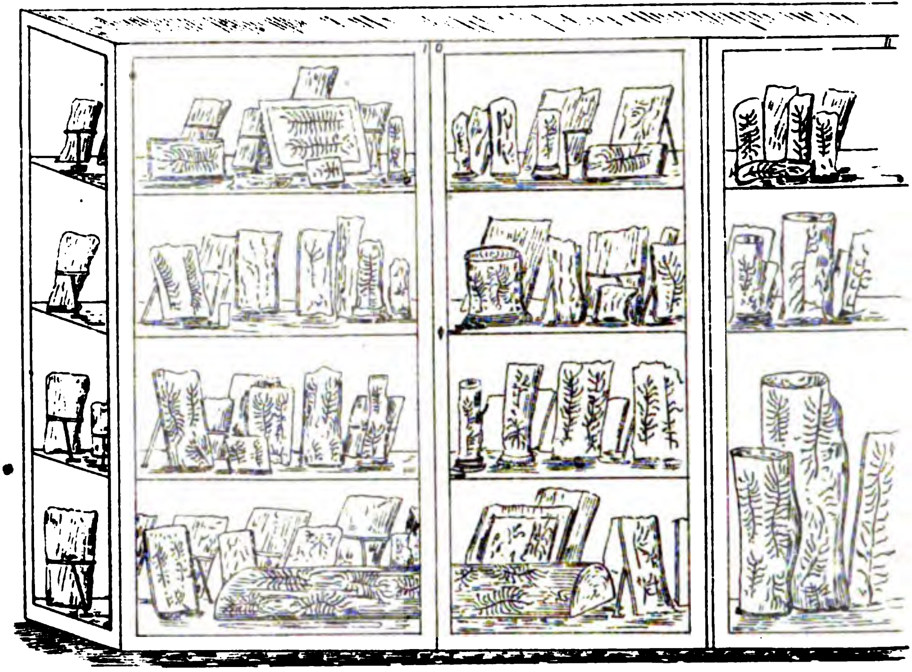

Fig. 2.

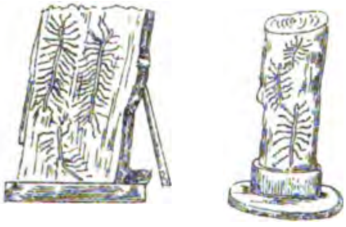

Fig. 3.

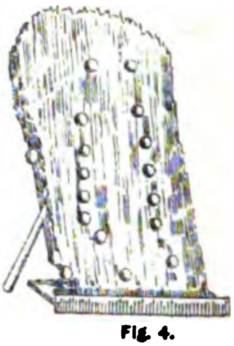

Fig. 4.

Fig. 2. The central case showing bark and wood attacked by *Scolytidæ* (Munich Museum).
Fig. 3. Method of exhibiting specimens of attacked bark and wood (Munich Museum).
Fig. 4. Holes made by *Picus* in bark to get at the grubs of *H. micans* feeding on it (Munich Museum).

(to face page 5)

Photo.-Mechl. and Litho. Dept., Thomason College, Roorkee.

Zinco., February, 1906—No. 1621-1

The zoological collections are not, as yet, completely arranged; the birds and mammals have still to be finished.

The Economic Entomological collection is practically complete. A large part of it is contained in two white central cases in the Museum gallery. These cases are practically all glass, the glass panes being fitted on to narrow wood frames so as to render the interruptions to a full view of the contents of the case as small as possible. The central cases are each 9 × 2 × 1·33 metres and each is double, *i.e.*, has two fronts (*vide* Fig. 2).

These cases contain the whole of the collection of barks, woods, shoots, fruits, etc., attacked by pests in the various orders of insects Other wall cases show birds, mammals, etc., and the general collection of insects is also shown in cabinets elsewhere, as are the less important amongst the invertebrates.

Description of contents of central cases.

The central cases are divided into 24 sections ,entirely devoted to exhibits of economic entomology. The most important feature, next to their arrangement, about these collections is that wherever necessary large specimens of affected bark or wood several feet in length, or whole sections of trees, are exhibited. In this way instead of showing one example of the gallery made, *e.g.*, by a bark boring beetle in the bark, a number of galleries are exhibited, some complete some partially so, as actually found in nature. It is of little use for the student to learn the typical gallery made by a particular beetle when more often than not he will, in nature, find only portions of these galleries. Further, instead of showing one specimen of an attack, a long series are shown. Where necessary enlarged painted drawings are placed alongside the objects.

Bark exhibits are shown erect fitted on to small metal frames, the wood specimens being fitted into metal sockets (*vide fig.* 3). Where defoliated leaves are shown they are mounted on card board with a gelatine covering in the form of a thin plate. These plates are very cheap and very light. Pupæ and grubs are exhibited in spirit.

Section 1 is devoted to exhibits showing dissections of insects with microscopic slides of antennæ, wings, mandibles, legs, etc.

Sections 2-15 are confined to the great and important order of Coleoptera. The exhibits commence with the damage done by the family Buprestidæ, examples of the noxious genera Chrysobothris and Agrilus being shown. The family Elateridæ (includes the wire worm) and Lymennoxylon, Anobium follow succeeded by useful predaceous species of Clerus (Cleridæ).

Sections 3, 4 and 5 are devoted to the weevils (Curculionidæ), Brachyderus, Otiorrhynchus, Hylobius, Pissodes, Attelabes, Rhynchites. The damage done by the Hylobius pest is well and fully shown. Rhynchites, the leaf rolling insects, are represented by a fine series of rolled-up leaves in glass topped boxes and glass bottles; in India this genus is represented by *Apoderus* whose members act in much the same way.

Section 6 to 13 inclusive, or one-third of the whole central cases, are taken up by the important family Scolytidæ and the collection of this family here shown is probably one of the finest ever got together. In the introduction characteristic examples of the action of Scolytidæ on root, wood, bark and foliage are shown. Coloured drawings then depict the chief shapes possessed by Scolytidæ, *i.e.* Scolytus, Hylesinus, Tomicus, Platypus. The insects themselves are not shown here with the damage done. I think it would be advantageous to show an enlarged coloured drawing of each insect whose work is exhibited. In the first group, Scolytini, the work of Eccoptogaster and Scolytus destructor is shown. In the group Hylesini the attacks of Hylesinus piniperda, minor, palliatus, circularis, ater, ligniperda, attenuatus, angustatis, opacus, micans (fig. 4 shows a piece of bark riddled with the holes of the wood pecker Picus in order to get at the grubs of this species feeding in the cambium; the exhibit is shown in a thin double glass-faced box in order that the exhibit may be handled and inspected in safety). Hylesinus (Polygraphus) polygraphus, subopacus, grandiclava, crenatus and vittatus are also shown. Amongst the exhibits of the damage done by the Tomicini are Tomicus typographus, ametinus, chakographus curvidens, piceæ, sexdentatus, proxinus, antographus, laricis, suturalis pusillus and lineatus. Platypus, an unimportant group in Europe but which is proving the contrary in India, brings this family to an end. Examples of the damage done by the rarer Scolytidæ are also included but these are not treated of in the lectures. Students who wish to do so are allowed to study them.

Sections 14 and 15 deal with the Cerambycidæ the work of Ergates faber, Aromia, Callidium, Cerambyx, Lamia, Saperda and Oberia being shown. The chrysomelidæ or leaf-eating beetles follow, the methods of defoliation being shown beneath the gelatine plates.

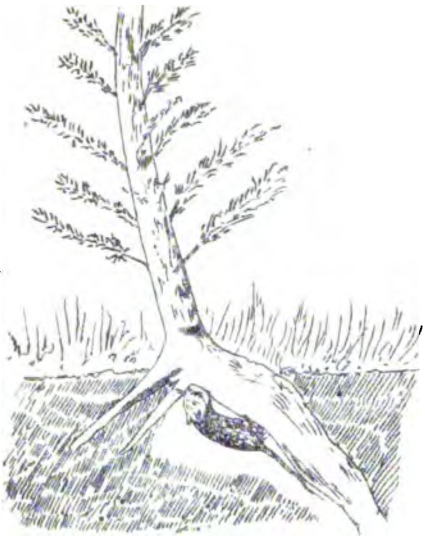

Fig. 5.

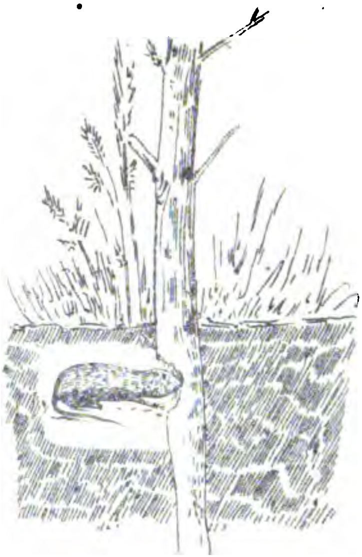

Fig. 6.

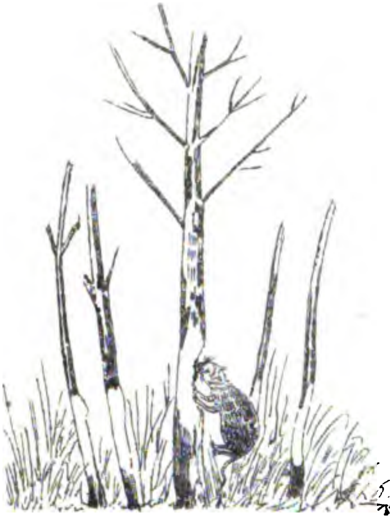

Fig. 7.

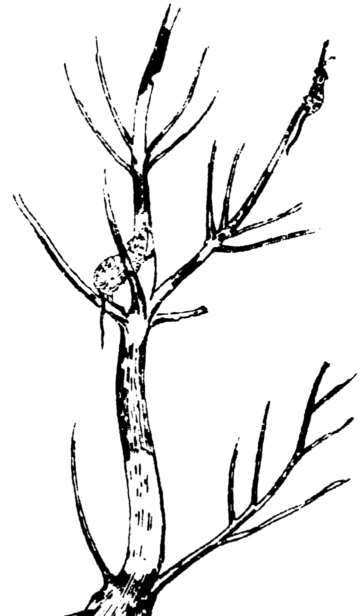

Fig. 8.

Figs. 5, 6. Mice gnawing roots of young conifers (Munich Museum).
Fig. 7. Mouse gnawing base of stem of a young conifer (Munich Museum).
Fig. 8. Mice gnawing away the bark on the branches (Munich Museum).

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Sections 16 to 20 inclusive are devoted to the Lepidoptera Heterocera (Moths), the Rhopalocera or butterflies being un-represented since they are unimportant in forestry. The pest Liparis monacha is shown in full detail, both its own action in the forest and the means taken to combat it. A fine series of photographs in this connection together with all the literature concerning this insect are also present in the case. Opportunity was taken of a bad infestation of the pest in the forests near Munich during 1890-91 to make these collections. The attacks of Trachæa piniperda and Fidonia piniaria are also shown. The wood boring moths are represented by Sesia, Cossus and Hepialus. The damage (deformed shoots and defoliation) due to the Microlepidoptera-genera Retinea, Tortrix, Grapholitha, Tinea, Hyponomeuta is well shown.

Sections 21 and 22 exhibit the cells, nests, galls, defoliation, etc., made by the Hymenopterous insects Vespa, Bombus Megaohile, Formica, Cynips, Lothyrus, Lyda, Sirex.

Sections 23 and 24 are confined to the Diptera, or flies (Cecidomyia, Tipula, Chloros), a good example showing the larval galleries of Tipula suspecta on the birch, the eggs being laid on the bark, and the Hemiptera or bugs, plantlice and scales. The attacks of cicada, Pemfigus, Schizozoneura, Chermes, Psylla and Coccidæ are shown.

The Wall cases.

Mammalia—Only noxious forest animals are shown.

Case 25.—Examples of damage done by *Sciurus* (squirrels.) A fine series showing damage to leading shoots, stems, fruits and seeds. Specimens of the animals themselves are mounted in the case showing the way they eat.

Case 26.—Mammalia (*cont.*)—

Lepus Myoxus, Castor, Mus.—

Stuffed specimens of the animals are shown in the case together with exhibits of the damage they do.

Two-thirds of this case is taken up with exhibits showing the damage done to various parts of young trees by mice. Figs. 5-8 show the way this damage is accomplished and the manner in which it is exhibited.

Cases 28, 33.—Aves—

This collection is not as yet completely arranged. Only birds important in forestry or met with in forests are shown.

Case 30.—

Picus.—A good exhibit of damage done by wood peckers with mounted specimens of the birds themselves. Specimens of Falco shown at bottom.

Cases 27, 29, 31 and 32, 34 and 36 are devoted to a general working collection of insects with the exception of case 34 which shows the life-history of L. monacha in the minutest detail. All stages of growth from the egg are exhibited and the method of feeding. Also examples of how the tar ring put on to the trees absolutely prevents the caterpillars climbing up the trunks to feed on the leaves. The bark below the ring is in severe attacks a thick mass of silk and larvæ. In cases of very severe infestations two tar rings are put on to the trees, the second stopping all larvæ which have managed to get over the first by crossing on a bridge of dead bodies and silk. This was done in the attack of 1890-91.

Scattered about the Museum there are also some trunks of trees showing damage done to them by (*a*) Picus and (*b*) Scolytidæ. (*c*) A stem is shown with the tar ring *in situ.*

The Lecture Hall.—This is a very fine large room and is used solely for the Zoology lectures.

General Insect Collection.—The rest of this collection is in cabinets in this hall.

Also many specimens used in the lectures, such as drawings of attacked bark specimens and wood shown in the lectures; a collection of skulls and, on the walls, a magnificent collection of the horns of mammals from all parts of the world.

The day before the Professor delivers his lecture all the specimens required by him are arranged by his assistant on tables in the lecture hall and the Professor can thus, if he wishes, go over his lecture beforehand. To deliver a course of Zoology lectures efficiently this procedure is essential and it will be seen that it is only feasible when a lecture hall is available for the Professor's sole use. Since the sides and walls of the hall can also be made use of to exhibit specimens it can serve to fulfil to a certain extent two objects.

Insects most injurious to forests.—Dr. Pauley is now taking out specimens of the insects most dangerous to forestry from the general collection and is arranging these in separate cases for easy reference by students.

Dr. Pauley and his method of Lecturing.—An opportunity was afforded of seeing the system on which Dr. Pauley delivers his lectures. It proved most interesting and instructive.

On a long low counter fronting the students' desks he has all his specimens disposed in the order in which he requires them during his lecture. At the moment he was lecturing on the important Hylesinus genus (*Scolytidæ*) of bark borers which commit great damage. I went through with him the fine series of damaged wood and bark examples he has collected in the course of years and also examined the drawings, made by himself, which he makes use of. He uses the black board freely and is strongly of the opinion that the student should as much as possible in his examination make use of diagrams. Drawing, or rather facility in making rough clear diagrams, he considers a *sine quâ non* to the forest student.

Summary of the collections.—Dr. Pauley's collections show that by far the most important class of the Animal Kingdom to the Forester is that of the *Insecta.* Therefore he gives these the greatest prominence in his arrangement. He places next some important *Mammalia* such as squirrels, mice, hares, etc. He gives these separate cases in order to fully illustrate the damage done by the several genera. Next we have some important Aves. The wood pecker (Picus) and examples of their destructive methods are given the larger part of a case.

The collections, although not completely arranged as regards the birds and mammals, completely fulfil the best ideals as to what is essential for the proper teaching of the forest students.

Specimens for Cooper's Hill Collections.—Dr. Pauley promised to send me a number of specimens illustrating attacks by insects, birds, and animals on forest trees, etc., for the English forestry collections.

Botanical Museums, Laboratories and Lecture Hall.

These occupy the basement and first floor of the old building which is thus devoted entirely to Zoology and Botany.

The Professor is Dr. Von Tuboeuf. The collections are very fine and great care has been paid to their arrangement.

Basement.—The Museums.—A small room and a large one (*vide* plan in figure 9) are devoted to Plant and Tree Diseases. The collection is of European specimens and is very complete. In the large room are four central cases and a number of wall cases. In the central cases

A, B, C, D, examples of the mycelia and fructifications of large Fungi on wood are shown. In the wall cases E—J, smaller fungi are shown in spirit. In another adjacent small room there is a series of exhibits of the seeds and fruits of trees arranged in glass cases.

A third small room has been arranged by Professor Tuboeuf himself and is quite unique. It contains a large series of portions of stems and branches of trees showing the results of lightning and the effects of electricity on the wood. The Professor is making a special study of this subject and the collection here shown is most remarkable.*

A fourth small room contains a collection of the woods of forest trees for exhibition during the botanical lectures.

It will be seen that the series of museum rooms has been very carefully planned and arranged.

First Floor.—The Botanical Laboratory.—A magnificent room containing every facility for study and research work. A collection of fungi (tree) in spirit is contained in a central glass case and a number of other objects on which research work was being undertaken were to be seen.

The Conservatory.—The laboratory opens out into a conservatory where all sorts of experiments in connection with "growth" are made. Some very interesting instances of the effect of various classes of soil and of light, etc., both on young seedlings and older plants were seen. Students who show promise are encouraged to work in the laboratory. Next to the laboratory are the Professor's and his Assistant's rooms, both well fitted, the former containing the botanical library. Beyond these is a fine lecture hall. It is used solely for botanical lectures, the walls being hung with diagrams of dissections of plants, etc.

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* Some important experiments and investigations are being carried out on this subject. Last year the Professor received a report that a number of trees had dead tops, the trunks remaining green. On making an investigation he found that some of the trees were attacked by *Scolytidæ*, but not all; in fact that the insects were only a secondary cause. Professor Tuboeuf then examined the trees which were standing in private woods, in gardens and elsewhere. Tuboeuf after careful examination found that the damage was due to lightning, and on consulting the meteorological statistics for the locality was able to prove that in the majority of cases the dead tops were due to the trees having been struck by lightning

This is most interesting, since it may aid the investigations into the cause of the numerous dead topped trees both in the hills and plains of India, for instance the silver firs at Deoban in the North West Himalayas, which have also been carefully examined for Scolytid attacks, but the reason of whose deterioration is still unsolved.

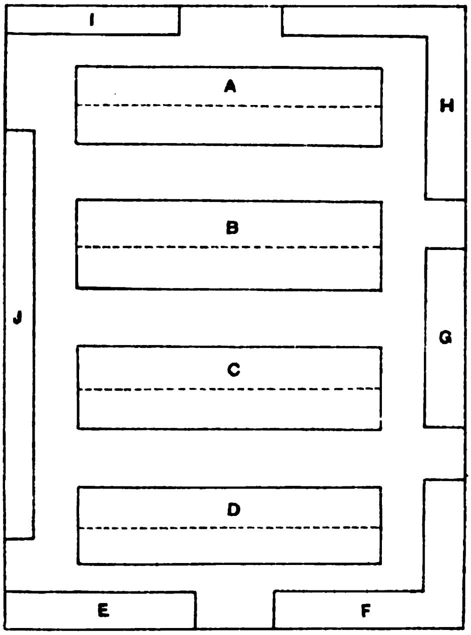

Fig. 9.

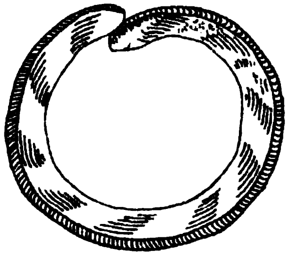

Fig. 10.

Fig. 9. Plan of Botanical Museum (Munich).
Fig. 10. A Russian Cart wheel formed from one tree—the bark still on (Munich Museum).

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A workshop room provides space for unpacking and packing specimens and cleaning work.

The Photographic Room.—The suite of rooms is completed by a fine dark room for photographic work, a very useful and important adjunct where research work is being undertaken. Some good cameras form part of the equipment.

THE NEW BUILDING.

The new building was designed specially for the purpose for which it is used and is thus probably the finest and best planned forest institute in Europe. The inside fittings are entirely of wood, highly polished parquet flooring being used throughout, with a great wide staircase and spacious rooms handsomely panelled. Each room is fitted with all the modern requirements for study and research. The building is fitted throughout with electric light, clocks, etc.

The basement.—Devoted to Chemistry, Mineralogy and Meteorology.

Chemistry.—The rooms comprise a fine chemical laboratory, a gas room, a large lecture hall, opening into both the laboratory and the mineralogical and meteorological museums, Professor's and Assistant's rooms, and an apparatus storing room.

Mineralogy and meteorology museums.—Fitted with glass cases containing a collection of stones and rocks, soils and a set of meteorological instruments on the same lines as those seen at other forest institutions.

First floor: Survey Instrument Room.—Examples of all instruments used insurveying, road alignments, etc., are to be seen here.

Forest Mathematics.—A large room hung with diagrams of yield, height, etc., curves. A number of yield and height, etc., calculating instruments are kept here—in fact examples of all the instruments invented. I was shown a wonderfully complex instrument designed to enable calculations of profits or deficits to be made. It is a most ingenious instrument, but not practical and only one example has ever been made.

Professor's and Assistant's Rooms.—These open out of the forest mathematical room and are adjacent to one another.

Forest Wood Museum.—Examples of all the European woods are kept here for use by the Professors during the forestry lectures and for reference by students.

The whole of the rooms on this floor form a suite, being so arranged that the articles required by the Professor during his lectures can be taken with ease into the fine Lecture Hall, whilst at other times they are always visible for the students to refer to.

Second Floor: Entirely devoted to Forestry and products from forests.

Forest Implement Museum.—A large room containing every instrument and implement ever devised for use in forest operations such as sowing, planting, trenching, pruning, felling, etc. The collection is most complete and the implements are shown either on brackets or, in the case of saws, hung on the walls, etc.

In addition to the implements there is also a large collection of the products and articles made from wood by the instruments exhibited *e.g.*, all stages in the manufacture of matches are shown, parts of wheels (a curious one was a Russian cart wheel shown in fig. 10 formed out of one single piece from the stem of the tree, the outer circumference still having the bark attached) rakes, harrows, etc. Also examples of various lathes.

Owing to the great size of the room there is place to exhibit everything in the most suitable manner.

The walls are hung with numerous photographs showing felling operations, logging, planting, etc.

Lecture Hall.—Opens out of the above room. The seats are arranged on the auditorium principle.

Professor's and Assistant's Rooms.—These open out of the Lecture Hall and are next each other. There is also an additional room used for experiments, etc.

General Forest Products Museum.—Models. This room is chiefly devoted to the products obtained from forests, our " minor products " in India. There are also some fine models, notably one of a Russian shooting lodge, made entirely of wood. Japanese wooden toys, etc., are also exhibited. Some fine examples of the mycelia of the Polyporus fungus on birch bark were of curious interest. They form a thick felt which can be used in a variety of ways.

There are also a number of fine models of timber slides, sledge roads, wire rope-ways, etc., shown here.

Third Storey.—The rooms here are smaller than those beneath. They are not as yet occupied by any collections.

Concluding remarks.—This completed the inspection of this remarkably well provided and up-to-date Forest College. As the above description shows, little fault is to be found with any of its details, and there is every incentive both to Professor and to student to undertake research work in any branch of forest study. The Bavarian Government pays for the up-keep, and in return that Government reaps the advantages derived from the very important research work in which its Professors, many of them possessing great European reputations, spend all their spare time.

b. The Eberswalde Forest Academy.

This is a Prussian School and fairly represents the Prussian methods of tuition. It is arranged upon the same lines as those indicated at Munich, but not so much space is available, and in consequence the Zoological collections are rather cramped. Some interesting points were noticed. The dried droppings of animals, birds and insects are shown in corked tubes in order that the student should be able to make himself familiar with its form and appearance, and thus enable him when in the forest to say whether an animal is abundant or not in a particular locality. The droppings of the more important caterpillars are exhibited in the same way. Another interesting exhibit is a series of tubes showing the different kinds of saw-dust ejected from or found in the galleries of various bark and wood-boring pests. This saw-dust often permits the determination of the nature of the insect at work by the colour of the wood-dust ejected. Professor Dr. Karl Eckstein, the well-known Author of 'Forstliche Zoologie' delivers the course of lectures at this Academy, and owing to his freely offered help it was possible to become fully acquainted with the methods of tuition given here.

Through the courtesy of Herr Oberforstmeister Reibel the whole of the rest of the Academy was inspected. It presented no notable differences from the Munich one.

c. Tharandt Forest Academy.

The Forest Academy at Tharandt is the only Forestry Institution in Saxony. It may be said to combine all the most advanced ideas for the education of the Forester and in the arrangement of the Museums, lecture halls, etc., we find a similar state of affairs to that already described for Munich. The fees for following the course are very moderate, and in 1904 the students numbered amongst them an Englishman from Scotland and another from New Zealand. The buildings are two in number, about 100 yards apart.

The main Building.—This comprises 2 storeys built round a small courtyard covered and lighted by large skylights. The basement and first storey consist of lecture halls, museums, etc. The top storey contains the quarters of the Director.

First Floor: The Library.—Each Professor has his own library in his own room or series of rooms and the main library consists almost solely of forest works. The books are all bound in the same leather binding and are well kept. The library is very well equipped with reference works.

Forest Lecture Halls, Museums, etc.—The only fault to find with this building all through is the want of space, most of the rooms being too small for the needs of the exhibits they contain. The lecture halls, especially the one used for the forestry and sylvicultural lectures, are of a fair size.

Museums:—*Forest Instrument Museum.*—Contains instruments for use in sowing, planting, felling, digging, trenching, lopping, etc. As the Professor, a Forstmeister, pointed out, many of them are not practical and are not used. It would perhaps be of some advantage were some check to be exercised on the inventive genius which turns out crank instruments complicated in detail and useless in practical work in the forest, which become simply lumber in the museums, but whose design and details the student is expected to make himself acquainted with.

Amongst practical exhibits seen in this Museum was a novel form of mouse trap for use in nurseries, etc. It is made almost entirely of wood. It consists of a simple box, the greater part of which is buried in the ground (see fig. 11). On either end near the top are two holes. At the lower edges of these is what appears to be a flat board or floor running right across the box from opening to opening. This board is divided in the middle and has a hinge at either end just below the hole. The mouse on entering through the hole tips the half board and drops down into the box below.

Animal slots.—A complete series of these in sand are preserved in long flat japanned-tinned boxes. It is an excellent method of showing these. The boxes are long, flat, with compartments of different sizes separated by small wood partitions (see fig. 12). The material is sand mixed with gum to give permanence to the impressions. The

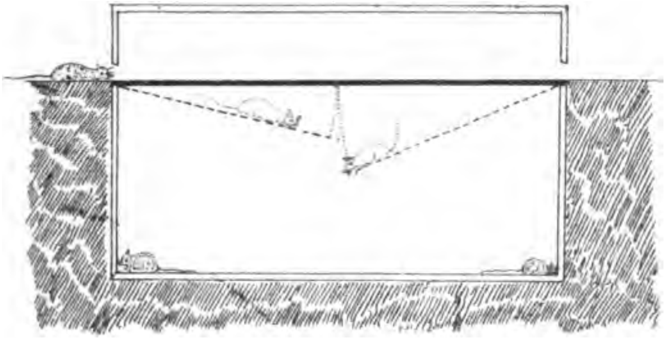

Fig. 11.

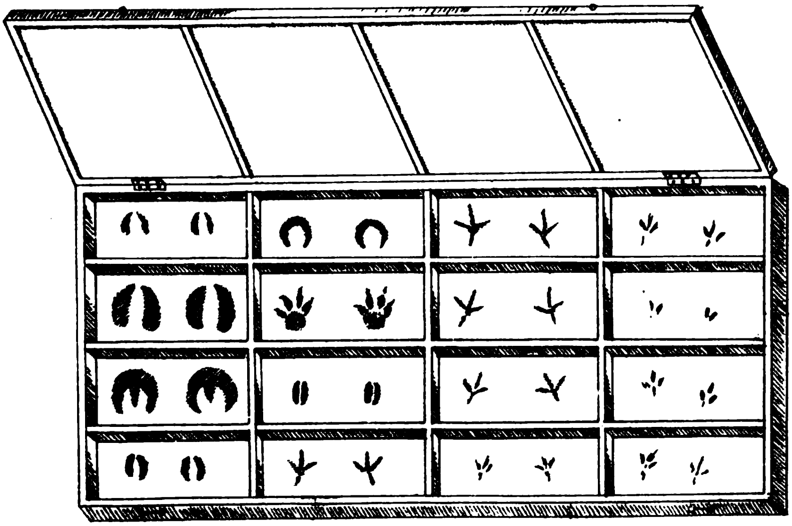

Fig. 12.

Fig. 11. A simple Mouse trap for use in Nurseries (Tharandt Museum).
Fig. 12. Method of exhibiting animal slot impressions (Tharandt Museum).

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series was carefully inspected as it will be possible to form one of Indian animals and the more important birds which should prove of considerable service in teaching the students a little jungle lore.

Forestry Museum.—This Museum is fairly complete and of a fair size. The plan (fig. 13) shows the arrangement.

Larger Room.—A fine collection (Cases 1, 2, 7, in plan) of European woods in small pieces in boxes and all named, resembling our collections at Cooper's Hill and Dehra.

Models.—There is a fine model (8) in chalk of a large slide in the Alps with sleepers lying cut at its head and others going down it and a depot at bottom. On the mountain slopes are shown roads, paths, streams, etc. There are a number of other models (2, 9, 10).

An interesting exhibit shows how toy wood animals are prepared (3). There is a fine series of resonant woods for instrument making, "bois de resonance" (5), as well as a series of barks (11).

Shot and bullets.—A complete set of all the different numbers of shot and also a series of bullets (12) is shown with a stand of rifles and examples of stick guns, etc.; these latter are shown to the students in order that they may learn to recognise and stop poachers. Saws, axes, etc., are shown in Case 6.

Smaller room.—A large series of European wood specimens (Cases 13—17) with examples of hypertrophy in wood, various wood fungi, sports, etc. (18). The fungus specimens are to illustrate the lectures given by the forest professors on woods, not for the botany teachers. With the same object in view there are a series of specimens showing damage to wood by animals, etc. This shows how the subjects overlap one another since the forestry professor lecturing on woods requires to illustrate his lectures by specimens used by the Botany Professor on the one hand and the Zoological Professor on the other.

Zoological Museum, etc.—The following are series of exhibits of special interest in this Museum.

Injurious Insects of Saxony.—About 103 in number, are shown in a box with their food plants and the various stages in the metamorphosis. Similar boxes have been set up and sent out to all Oberförstmeisters in each district in Saxony. They number 11, so that in addition to there being a box of these insect pests for reference at Tharandt, there are 11 others scattered over Germany. This is eminently practical.

There is a good exhibit of bark and wood attacked by insects in a vertical glass case. This rests on cabinets containing a general collection of insects. This latter commences by showing representatives of each of the different large orders of insects and then goes on to give examples of all the important families.

Judeich collection of European Coleoptera.—Judeich was Director of the Tharandt Academy before Neumeister and died ten years ago. He left his magnificent collection of Coleoptera to the academy. A careful examination showed that it was well worthy of the most careful study.

Carl. P. Sommers' collection of European Lepidoptera.—This is a very fine collection left by Sommers. The insects are all mounted in glass top and bottomed boxes as seen in the Dresden Museum and elsewhere and are in good preservation.

The possession of such fine collections is a great advantage since by their means the student is able to determine the insects he collects for himself and this acts as a great incentive to those who take an intelligent interest in the lectures and the subject. As there is always a resident zoologist in the place and he is always provided with an assistant, there is little risk of these fine collections coming to harm. Judeich's, as being the result of his great and valuable researches into the habits of forest Coleoptera, is invaluable.

Other Invertebrata.—The method of showing other Invertebrata is of interest. The lower groups of animals are represented sparingly either natural specimens as in case of sponges, corals, etc., or, where necessary, in glass tubes either dry or in spirit.

In a small cabinet are a good set of microscopic slides showing amœba, hydra, parts of insects, etc. Fig. 14 shows the method of exhibiting fish in spirit.

Beneath the central case are cabinets containing the general collection of insects.

Entomological Botanical Collection.—They are just commencing here a botanical collection showing the method of defoliation ot various different kinds of insects and the methods in which leading shoots and twigs are eaten.

The Assistant is most skilful at mounting economic exhibits of insects and showed me several of his preparations.

Preservation of Coniferous twigs for exhibit purposes.—To preserve the needles on coniferous shoots he dips the shoot or

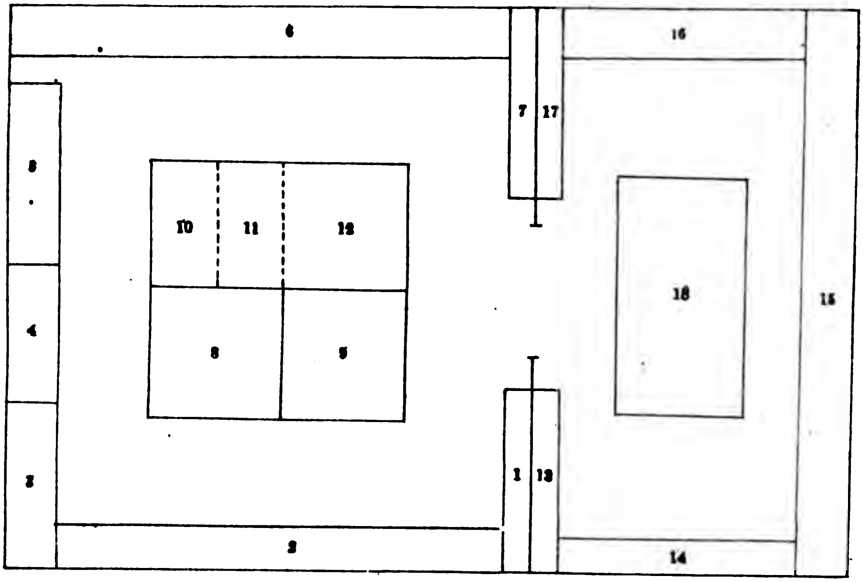

Fig. 13.

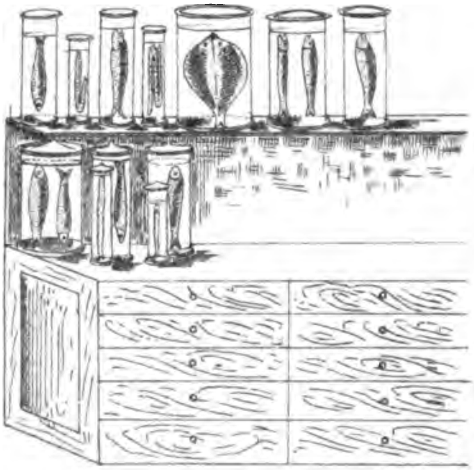

Fig. 14.

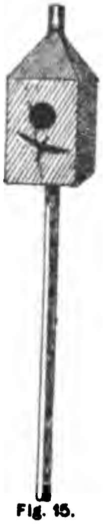

Fig. 15.

Fig 13. Plan of Forestry Museum at Tharandt Academy.
Fig. 14. Method of exhibiting fish specimens at the Tharandt Museum.
Fig. 15. Boxes erected in Germany to serve as nesting places for birds.

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branch into glycerine and water, ⅓rd glycerine to ⅔rds water. This fixes the *needles*, but the specimen has to be repainted with its natural colouring afterwards. They told me that the method of keeping the colour I was shown at Brussels will not do for conifers.*

Preservation of wood and bark specimens.—To preserve these they are all dipped into a weak solution of arsenic. If the specimens are dry first dip in spirit.

The Museum is perhaps most notable for the beautiful manner in which the economic collection of insects is set up, *e.g.*, some of the attacks of microlepidopterous larvæ on pine shoots are wonderfully mounted, the shoot being shown with its natural colouration and with the larvæ *in situ* in the tunnels.

Boxes for Bird nests.—A common sight in Germany are the boxes attached to long poles (see fig. 15) erected in gardens, parks, plantations, orchards, etc. A firm, Gebrucher Scheich of Buren i. Westf. turns these out in thousands at ½ a mark apiece. I saw a varied collection here adapted to different species of birds.

Insect Pests in Tharandt forests.—Chief are—Hylastes cunicularis; Tomicus typographus. T. lineatus in felled trees. Liparis monacha is bad at times. In the pine forests in the plains of Saxony there was a little damage by this insect last year.

The Botanical Museum and Lecture Hall.—An exhibit of interest in the Lecture Hall is a series of young seedlings, each showing the first leaves and root system. The seedlings are mounted on white paper mounted in glass frames. The collection of forest seeds is probably one of the finest in Europe as the Botanical Professor is a specialist in this subject. The seeds are exhibited in glass-stoppered bottles.

The smaller building.—The chemical, physical, meteorological and mineralogical museums, laboratories and lecture halls are housed here. The Chemistry Professor and his Assistants have a magnificent suite of rooms, laboratories and apparatus rooms at their disposal. In addition to the large common laboratory for the use of the students and Assistants there is a smaller one for the private experiments of the Professor. At the time the visit was paid the latter and his assistants were engaged in research work into tanning and dye products, in both of which they had high hopes of arriving at economic results of value to their Government.

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* To prevent the column 'flying' from a plant it is picked green, placed in a natural position, and hot sand allowed to fall over it until all the parts are completely buried. The plant thus retains its natural position in addition to its colouring.

d. The Aschaffenburg Forest Academy.

As already mentioned this is situated in Bavaria, the first two years of the Bavarian students' course being taken here. Non-Bavarian students complete their course at Aschaffenburg. In every case the Zoological course is taken at the latter place.

This course is given as follows : —

There are 16 weeks' vacation in the year The remaining 36 are divided into three semestres—

1st year—1st Semestre .	4 hours per week	Systematic course.
2nd Semestre	3 hours per week	
2nd year—1st Semestre .	2 hours per week	
1st year—1st Semestre .	1 hour per week	Pisciculture.
2nd year—1st Semestre .	Do. do.	
1st year—2nd Semestre .	4 hours per week	—Practical dissection of animals—Crayfish, mussel, frog, lizard, fish, pigeon, mouse.
2nd year—1 Semestre .	2 hours per week	—Practical systematic insect course.

From the time devoted to it, it will be seen that the subject is taught in a thorough manner. Owing to the kindness of the Director, Dr. Von Furst, I was shown all over the College. I was told that the college at Munich was a much better one. Being at the head quarters of the Central Government it was given more money and consequently the museums, laboratories, etc., were far superior to anything at Aschaffenburg. I deemed it therefore sufficient to make a thorough inspection of the Zoological portion of the College here. I found that in some ways it differed from the arrangements already seen at Eberswalde and Tharandt. Professor Dr. Spangenberg is in charge of the Zoological section and with his help it was possible to see everything of interest in this branch.

Fig. 16 shows a general plan of the arrangement of the 3 rooms. In room I cases 1, 2 exhibit the lower Invertebrates Protozoa and Cœlentera, Vermes, Echinoderms. In 3, 4 Molusca and Crustacea, 5, 6 fish, 7 Amphibia and Reptilia and 8 the first portion of Mammalia. Case 9 shows models of the internal parts of man's anatomy, 10 a general collection of insects. 11 is a window work table. Room II—cases 12 to 15, 17, 19 and 20 are devoted to birds and their anatomy, cases 16, 18, 21 to 24 to insects—general, economic and mimicry. Case 24 is shown in Fig. 17. Room III—cases 31 to 33 show the balance

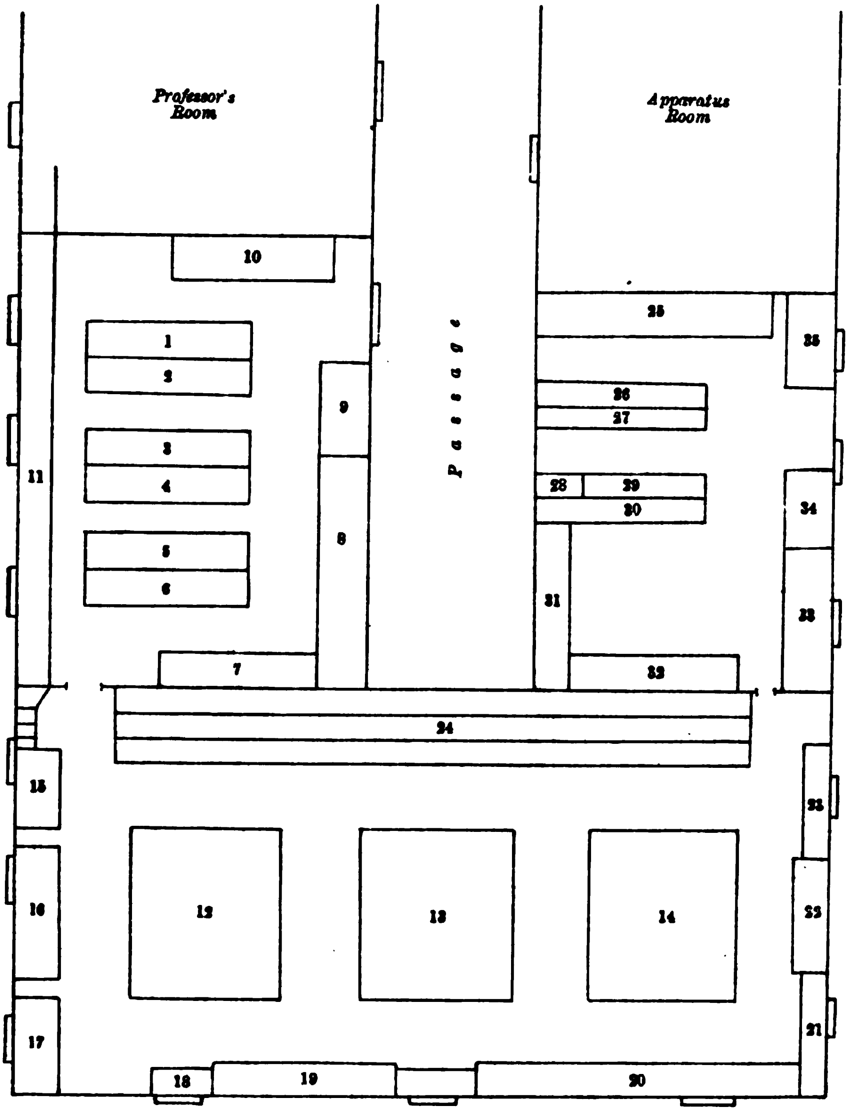

Fig. 16.

Fig. 16. Plan of Zoological Rooms at the Aschaffenburg Academy.

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of the insects 25, 26, 30 skeletons and skulls of Mammalia, 27 intestinal parts in spirit, 28, 29, 35 teeth, respiratory system and models of ear, eye, brain, etc., case 32 Albinism and melanism in birds and 34 examples of the outer covering of animals such as shells, skin, hair, horn, feathers, also adaptations for flying such as feathers, etc.

The Zoological collections are perhaps chiefly remarkable for a very fine collection of skeletons and skulls. This is much more complete than the collections seen elsewhere. A point of interest in connection with the Entomology portion of the lectures was the Professor's device of slipping cases of insects into small grooves in a long bench and thus safely exposing them to the students' view whilst the particular families were being treated of, without any handling by the latter being necessary. Fig. 16 shows a general plan of the Zoological Rooms. Fig. 17 the arrangement of wood specimens attacked by insects in this museum.

2. THE ST. PETERSBURG IMPERIAL FORESTRY INSTITUTE.

The Forestry Institute at St. Petersburg is the largest forestry college in Europe. The students number 500. The lecture halls, museums, laboratories, etc., are situated in a larger rectangular block of buildings. In the grounds, which are extensive, stands another fine building, the residence of the Director, whilst others contain the quarters of the Professors (12 in number), Assistant Professors (15) and students (latter in a separate block). The grounds are prettily planted chiefly with *Pinus sylvestris* and Birch, the latter giant trees compared to anything we know in Western Europe.

The students' course at the College extends over a period of four years, approximately 125 students entering the Institute each year, an equal number passing out. At the end of the course two or three are selected from the best students, if they are deemed likely to profit thereby, and given an extra two years' tuition. This period is spent abroad, one year in France and one year in Germany at the expense of the State. The Professors at the College are subsequently chosen from these men. The present Director, M. E. Kern, spent a year at Nancy and another at Tharandt.

The students whosatisfy the examiners at the end of the course are at once given appointments corresponding to our assistant conservatorships and obtain charge of a forest division three to four years after first appointment.

Lower grade Schools.—In addition to the Institute from which all the officers of the superior service are drawn there are 33 lower grade schools with 15 students in each. The course in these schools lasts for two years (thus resembling the Dehra School) and the whole of the lower grade positions corresponding to our Rangers, etc. are filled by the men issuing from these. A student from a low grade school can never hold charge of a forest division it being clearly recognised that his training is quite inadequate. He is taught actual forest work but no attempt is made to fill his head with such intricacies as the preparation of working plans and the important details connected with what may be called the higher sylviculture. It is recognised that the forests are a property too valuable to be put in charge of men of a low intelligence and education since sylvicultural mistakes are easily made but take years to repair. About 250 students leave the lower grade schools annually or double the number quitting the superior service Institute.

The Imperial Institute Building.—The arrangement of the rooms and collections follows the best of the German methods, each subject being given its own suite containing museums, lecture halls, laboratories and professors' rooms. Considerable additions to the building have recently been made with the result that splendid accommodation is now available for all. This question of separate museums, *i.e.*, separate rooms being available for the arrangement of the collections of each particular branch of tuition is one of the very first importance. It has been shown that such are always present in the German Colleges. The arrangement by which, owing to inadequate building accommodation, Forestry, Botanical, Geological, Zoological, etc., collections are all jumbled up together is inconsistent with the proper teaching of the student. When studying, for instance, botanical specimens it is scarcely of advantage to have attention distracted by Zoological specimens close by. From heterogeneous masses of specimens of different branches of his work mixed together in one or more galleries the student will gain little good.

Little need be said regarding the arrangement of the museums, etc., since it follows closely those already described for Munich. There are one or two points of interest however.

In the Botanical Museum young seedlings of the chief trees up to three to four years old are shown whole with the tap root development and the portion above the ground. They are fixed to large screens consisting of a wooden frame holding a thick sheet of drawing paper or thin cardboard to which the seedlings are attached as shown in fig. 18.

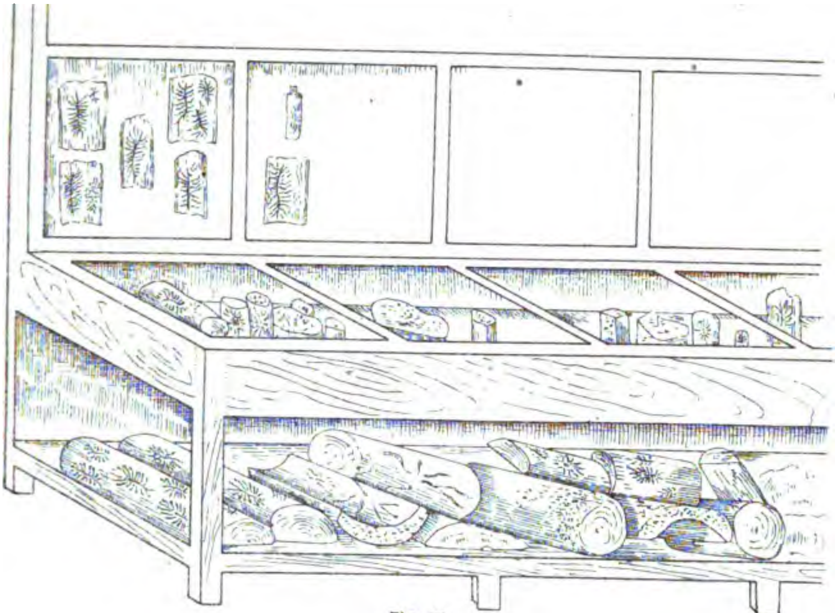

Fig. 17.

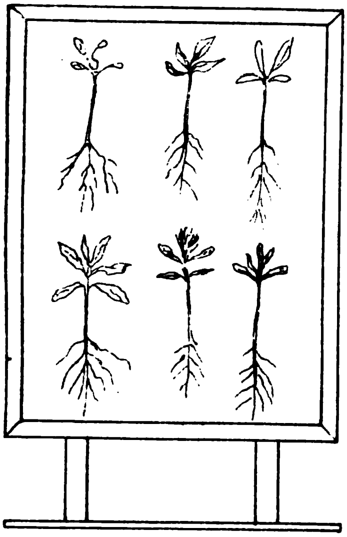

Fig. 18.

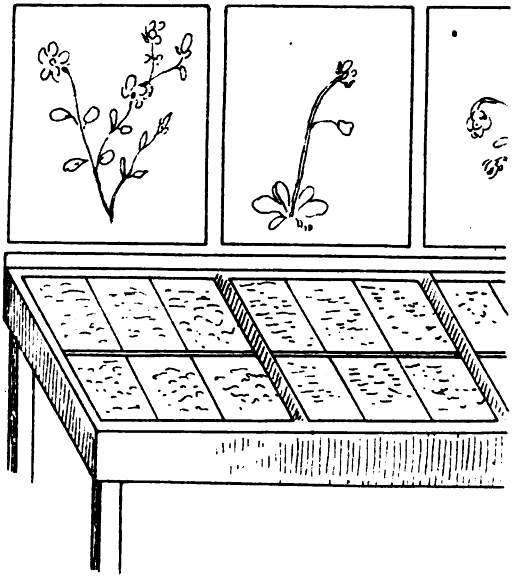

Fig. 19.

Fig. 17. Method of exhibiting wood specimens attacked by insects (Aschaffenburg Museum).
Fig. 18. Seedlings showing root system and first leaves (St. Petersburg Museum).
Fig. 19. Method of showing soils and plants chiefly characteristic of them (St. Petersburg Museum).

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There is no glass front to protect the plant. The frames stand erect on the top of herbaria cabinets and can be easily examined by the student.

Chemical Museum.—In this Museum a large number of the most important Russian soils are shown in narrow glass-topped boxes placed side by side on a sloping desk about 4′ high. The name is placed beneath each soil. Above the desk on the wall is shown a mounted specimen of the plant which is chiefly characteristic of the soil (see fig. 19). This specimen is fixed to an ordinary cardboard or thick drawing paper mount. A full set of the apparatus used in Russia for the chemical analysis of the soils is also exhibited here. Simple analyses of soils are shown to the students in order that they may become acquainted with the method by which they are carried out.

Examples of the rocks from which the most important soils are derived are also shown in the Museum.

Mineralogical Museum.—A large collection of the various rocks found in Russia together with fossils found in the strata are exhibited here. Also coloured geological maps showing various formations.

Zoological Museum and Rooms.—This Museum is large and when it is noted that it is almost entirely the work of Professor Dr. Cholodkovsky, who has a great reputation as a Scientist and worker in both Anatomical and Biological Zoology, it will be understood that it is of the best.

The Professor has a working room of his own, another for his Assistant and a third which forms a general laboratory for the students. There is also the lecture hall and finally the Zoological Museum. The arrangement of this latter is much on the same lines as that seen at Munich and therefore does not need full description. One or two points deserve mention.

Firstly, a very fine collection of *Aphidæ* in spirits and also the portions of trees infested by them. This is a subject in which Dr. Cholodkovsky is a specialist of world-wide reputation and the collection is probably unique in its thoroughness. It consists of European species only. Fig. 20 shows the method of arrangement of this collection.

There is also a representative and interesting collection of Siberian animals and insects.

Zoology lectures.—Two hours a week are given for seven months in each year for the first three years of the students' course.

3. THE VIENNA FORESTRY AND AGRICULTURAL COLLEGE.

This college, termed the Hochschule, is intended as a training institution for foresters, land agents and agriculturists. The building is quite new and about 400 students attend the various lectures.

Owing to the different training required by the various classes of student the arrangement of the lectures differs somewhat from that of an ordinary forest college. For instance such subjects as Zoology, Anatomy, Plant Physiology, Chemistry, Elementary Botany, Geology, Surveying are taken in the first years and general courses in each are delivered to the whole of the students. The latter having had these courses then begin to specialise in the subjects of their different professions. The forest students in addition to their forestry lectures are given a course of Forest Entomology, Forest Botany, etc.

The Forest Building—Consists of a basement and two floors. In the basement are situated the rooms devoted to Zoology, Anatomy, Botany, including the museums in these subjects.

Zoology and Anatomy.—The subject is taught from a general point of view by a Professor who has nothing to do with the teaching of the special courses required by the students when they commence to specialise. He simply confines his lectures to giving the students a good grounding in the subject. They are then ready to fully understand and appreciate higher special courses. There can be little doubt, and many of the German Professors hold this opinion, that the forest student should always be taught in this way. The time that can be given to the study of Zoology even in the long German course of forest instruction is always far too short to enable the subject to be dealt with properly, and it always proves absolutely necessary to cut down the initiatory lectures to the very smallest limit. When the students have already been well grounded in elementary principles the forest Zoologist is in a very different position and the students themselves obtain a much greater profit from the lectures. The mistake made here, however, is that the subsequent course is in Forest Entomology only instead of Forest Zoology as a whole.

On the second floor are the rooms devoted to forestry, forest accounts, land procedure and lecture hall and on the top floor forest zoology (Entomology). In buildings separate from the main block but close to it are the chemical, physical, geological, mineralogical and soil museums, laboratories and lecture hall.

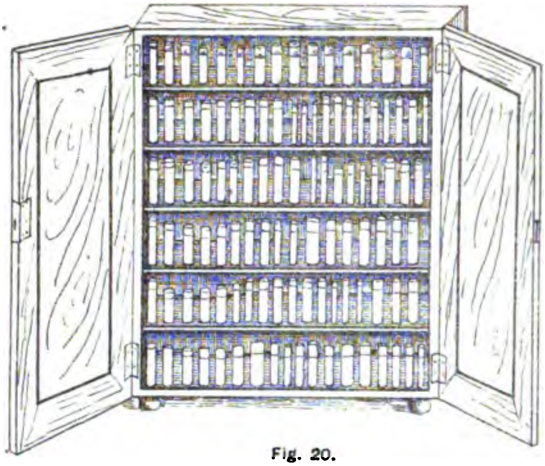

Fig. 20.

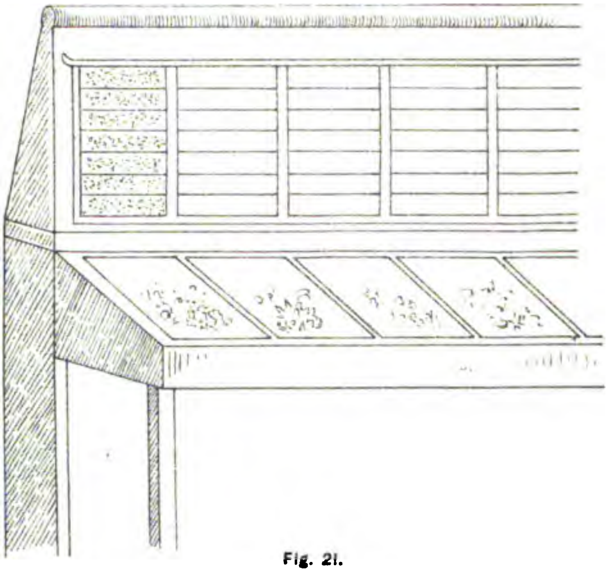

Fig. 21.

Fig. 20. The collection of aphidæ in the Zoological Museum, St. Petersburg Forest Institute.
Fig. 21. Exhibit of seeds and fruits at the Nancy Forest School, France.

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Forest Entomology (*Zoology*) *Museums, etc.*—A suite of three rooms is devoted to this subject. The collections are not purely entomological since they contain also birds and mammals but the course delivered by the Professor, Dr. F. A. Wachtl, is limited to forest Entomology and in fact almost exactly resembles the course delivered to the forest students at Cooper's Hill. There is this exception, however, that the Austrian forest students have already had a good general grounding in Zoology and Anatomy. Even with this, however, the procedure by which Forest Entomology only is taught is a wrong one. It limits the subject to the damage done by insects only and yet there are numerous other noxious animals which the forest student requires to know and to know well, vermes, snails, reptiles, snakes, squirrels, lepus, mice, rats, bats, etc., etc. The families to which these belong are touched upon slightly in the first general course but the animals are not mentioned at all in the forest entomology one.

4. NANCY—ÉCOLE NATIONALE DES EAUX ET FORÊT.

Situated in the town of Nancy at a comparatively short distance from the mountainous Vosges in which many ideal forests are to be seen, the French forest school is placed in a position peculiarly favourable for the effective training of the students. It is the only school in France, all the future members of the upper controlling staff being trained here. The students spend two years at the school, the total number being usually 36, 18 entering in each year. These students mostly come from the great Agricultural College at Paris, two years having been first passed at that place. At this latter Institute all students spend two years in a general grounding in elementary science courses, mathematics, etc., and at the end of the two years they choose, according to their position on the list, their future profession, forester, land surveyor, officer in charge of Agricultural farms, etc. The men at the top of the list generally choose the forester's life provided they have private means to enable them to do so. Thus a really good stamp of forester is obtained from Nancy.

The School Building.—This, with the additions recently made, is large and commodious, containing museums, laboratories, lecture halls and students' working rooms. The top floor of the main block consists of quarters for the students, a room with dressing room being apportioned to each pair. Private students, of which there are generally several at Nancy, live outside. All the students make their own messing arrangements outside in the town. The building also contains the Director's office, Secretary's office, and a private working room for each Professor. There is a large students' working room for each year and a club room fitted with billiard table, etc., common to all.

The staff.—The staff is very much undermanned and compares in this respect very unfavourably with that of the German forest colleges. The professors number seven only all told. They teach respectively Forest Law and rights, forest mathematics, Sylviculture, Amenagement, control of mountain torrents, etc. (*i.e* forest engineering), Zoology and soils (Geology to a certain extent) and forest protection (to a certain extent), Botany. An eighth man who is on special detached duty gives a course of pisciculture (usually the work of the Zoologist here).

There are no assistants.

The Professor of Zoology, M. Henry, does the work of two, if not three, professors in the German Colleges, and each of these would have the benefit of an assistant's help. This results in two things:—

(i) The Professor, who is primarily selected owing to the value of the research work he has done and the name he has made for himself in the scientific world, finds that his whole time has to be given to the mere teaching. He has but little time available to answer the numerous queries and examine the numerous specimens he receives from forest officers all over France (for Nancy is the experimental and research station as well as the teaching institution of the French forester) and practically none in which to conduct researches and publish notes which would be of the very first value to French forest officers and consequently to the Government.

(ii) The absence of assistants throws everything on to the professors and results in much waste of their time. In Germany we have seen that the assistant prepares the lecture hall, puts out the instruments, specimens, etc., required, following the system obtaining in all Universities of importance. But this is not all. The assistants are responsible for the condition of the collections, help to set

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Directeur, Sous-Directeur, Jolyet, Huffel, Thiery, Henry, Guinér, taking subjects in order named above.

up new specimens, and in fact perform the thousand and one small things which, whilst giving an excellent training to them, is pure waste of valuable time if done by the professor himself.

Description of Museums.—The rooms are not arranged on the plan or in the suites found in the German schools and the same applies to the collections. These have been added to at different times and new wings built to accommodate the increases, and thus in two of the museums at least there is a most confusing mixture of objects: woods, animals, rocks, situated in cases adjacent to one another. This is not now due to want of space, though formerly this reason could have been advanced. It is said to be due entirely to the shortness of staff.

The Surveying Instruments' Museum.—This contains the usual collection of surveying and road alignment instruments.

The rest of the collections of the school are situated in four museums, the newest of which, the Gallerie Daubrée, is a separate building in the grounds.

These four museums may be shortly described as follows:—

I. *Devoted to*—Insects, wood specimens, parasitic forest fungi, forest seeds.

Gallerie Mathieu—Consists of a series of seven rooms containing minerals, fungi and exotic woods, birds and nests, fish, mammals, vegetable palæontology, animal palæontology.

III. *Pavilion de Mahey.*—European woods, Indian woods, French woods, forest implements, models.

IV. *Gallerie Daubrée.*—A handsome gallery exhibiting examples of the various uses to which woods are put. Forest fungi. Traps. Forest products.

Whilst the collections in these museums are more or less similar to those contained in the ones already described, a few points of interest require consideration.

(1) *Insects.*—An economic collection of insects is arranged so as to show together all the insects attacking a particular tree. All stages of the insect are shown and parts of the tree affected; *e.g.*, all insects attacking the oak are shown in a series of boxes (since they are too numerous to go into one box), those infesting the Scotch pine in other boxes, similarly those attacking the beech, the elm, ash, etc. This

method, provided it is given in addition to the ordinary economic collection, is an excellent one since it enables the student towards the end of his course to form a general estimate of the importance and number of the insects attacking a particular tree. Also officers stationed in parts of the country where only two or three trees are of importance can, by making a trip to Nancy, in a very short space of time refresh their memories on the subject of the insects they will have to encounter. That the idea has not been developed in Germany is usually, I think, due to want of space. As we shall see later M. Henry only makes use of these collections towards the end of his course when the students are in a position to be able to understand and appreciate the value of the collections. These cases were prepared for an exhibition and afterwards given to the school.

(2) *Mathieu collection of Coleoptera.*—M. Mathieu, whilst Professor at the school, made a very fine collection of Coleoptera from all parts of the world. These he left to the school on his death. They are in book boxes arranged on shelves like volumes. It is a general collection, not an economic one. The importance and value of such collections to a forest institution has already been alluded to elsewhere in these notes.

(3) *Exhibits of the more important insects infesting trees.*—This is a small collection of some 20 small boxes, each containing a particular noxious insect, set up with all the stages of its metamorphosis and parts of tree damaged. These are hand specimens intended to be shown at lectures; they are 'shop' specimens and bear all the impress of the trade about them. Personally prepared ones are preferable but the idea is an extremely useful one and well worthy of imitation.

(4) *Economic collection of insects.*—This is arranged in cabinet drawers. It is both economic and general. Small examples of the damage done are shown with the insects. All the most important families are sown with the chief genera and species under each A good idea is that at the head of each family a label is attached with a note as to the chief habits of the group or family, *e.g.*—

Carabidæ.
Chiefly carnivorous animals and so of use in forest.
Larvæ found in dead wood, carnivorous.

Cetoniidæ.
Not of importance. Imagoes on flowers.
Larvæ in dead wood.

Forest seeds, fruits.—These are contained in two central cabinets; each of these consists of a central double-faced erect case with flat desk cases on either side (*vide* fig. 21). The erect portion contains forest seeds in flat glass-topped boxes whilst the desk contains forest tree fruits. These fine cabinets were specially prepared for the Paris Exhibition, 1900, and were subsequently presented to the school.

Two things are observable:—

(*a*) Absence of any large collection of barks and woods attacked by insect pests as shown so well at Munich.

(*b*) The confusing mixture of botanical and zoological specimens.

Students' General Working Room and Laboratory. – In this room Henry has had two long strips of wood, grooved on the inside, fitted on one of the walls. These are so placed that the economic insect collection drawers can be slipped in and locked in. Whilst lecturing on particular groups of insects he slips in the boxes containing the insects he is talking about and leaves them here for a fortnight or so before changing them. The students can thus refer to them at any moment they wish to. It is a good idea on the same lines as already seen at one or two of the German schools, but carried to a greater degree of perfection. I noted that botanical specimens were also treated in the same way.

The Zoological Course.—At the Agricultural College, from which most of the forest students come, they receive a good grounding in general elementary Zoology and also in Agricultural Entomology. It need hardly be pointed out that this is invaluable to a student who wishes subsequently to follow a course of forest Zoology and it is equally so to the Professor who delivers the course. Without wasting time on introductory lectures on general principles and others on the lower groups of the Animal Kingdom of no importance to the forester, but which must be touched upon in order that the student may understand the position occupied by the various animals living on the earth and in its waters, the professor can proceed direct to the important groups which the forester requires to have full details about. In this one thing the students at the French school are in the same position as those at Vienna, and this is where the German schools fail.

The following is the course delivered by Professor Henry.

Second year:– Forty-six lectures are given on Insects and Vertebrates, each lecture 1½ hours.

Insects.—Four lectures are given on structure, metamorphosis, etc. He then deals with the orders according to their scientific position. At the end of the course 4 lectures are given on the insects which attack individual trees and during these the cases specially arranged in this manner are shown. He takes the chief trees one by one and gives the list of the most noxious and dangerous insects attacking each, recapitulating shortly the life-histories of the most dangerous ones. The advantage to the student of this course is easily seen. There are also some special lectures for practical work.

Professor Henry's other lectures.—In all the professor delivers 76 lectures. Twenty of those not detailed above are given in the first year on forest soils, their formation and combination. The chief rocks and soils of France are shown and the remaining ten lectures are delivered on forest fungi. If time is available 5 or 6 lectures are given on the Geology of France.

5. THE FORESTRY BRANCH, R. I. E. COLLEGE, COOPER'S HILL.

On return to England from the Continental tour it was considered that it would be of advantage to visit the Forestry Branch at Cooper's Hill with a view to comparing the arrangement of the rooms, museums and collections with those seen in the colleges abroad.

The rooms and laboratories for the subjects Chemistry, Physical Science, Geology and soils are common to Engineer and Forest student alike and are replete with the necessary modern apparatus.

Coming to the more purely forest subjects, with the single exception of Botany, neither the space available nor the collections themselves can be said to compare at all favourably with the best of the German colleges. The space devoted to the forestry collections pure and simple is much too small whilst zoological collections are conspicuous by their almost complete absence.

The forest branch may be said to comprise seven rooms (fig. 22) of which rooms 4, 5, 6, and 7 in the plan are devoted to Botany. A botanical museum added to these would have rendered this branch complete.

Three rooms are devoted to forestry, but the available space compares very unfavourably with that allotted to the subject in the German, Russian, Austrian, and French schools. The Forest and Botanical Library is situated in the small lecture room (room 1). The walls are

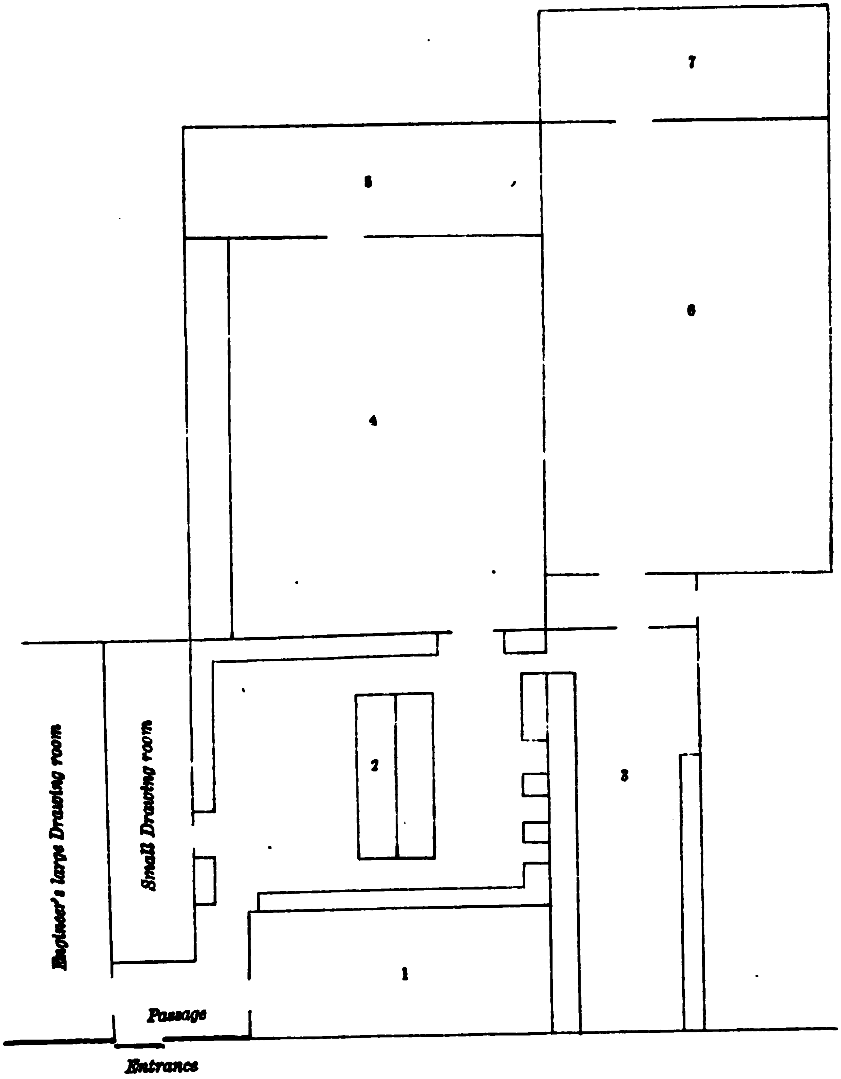

Fig. 22.

Fig. 22. Plan of rooms of the Forestry Branch, Cooper's Hill College.

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hung with a series of forest maps of the different provinces of India and with some large general maps of the country.

In the second room are the collections of woods, implements, models, and photographs; also seeds and minor products. Owing to the small size of the room (about one-third of the wood gallery at the Dehra School), the objects are all placed close together rendering their study a difficult matter.

The third room, which is little more than a narrow closed in verandah, is devoted to damage and diseases of trees ; the greater part being specimens of botanical damage or that due to the effects of lightning, frost, hail and other mechanical injury. A collection of seeds is also exhibited here.

In a small space are the few examples of injury done by insects and other animal pests of the forest, the collection being extremely poor.

It is scarcely necessary to point out that neither in accommodation nor abundance of specimens (the latter being a result of the former) can these museums compare favourably with those seen in Germany, Russia, Austria and France. It will be conceded that the provision of really good museums is an absolute necessity of a Forest College, an absolute *sine quâ non* if students are to properly assimilate the lectures they attend.

The Forest Insect Collections.—As compared with the German, Russian and French these are almost non-existent. If compared with the Munich standard they may be said to be entirely so. The small collection of hand specimens shown in the third room comprise the whole of the exhibits. In addition there are some 20 old store boxes containing a general collection of insects, an exceedingly small one. These boxes are about 2′ × 1′ × 3′. There are also four very old cases, probably presented by the Nancy Forest School, which were prepared in France. One of these contains some beetles, the others small hand specimens of the attacks of a few Scolytidæ and other wood-borers.

This comprises the whole collection available for study.

The Botany course at Cooper's Hill is not confined to a portion only of the Vegetable Kingdom—to the orders which contain trees met with in Europe and India. The whole of the Kingdom is dealt with and the position occupied by its different members fully explained. Yet while this has been recognised as a *sine quâ non* for Botany, in the case of the Animal Kingdom the one class *Insecta* or at most the group *Arthropoda* is all that is touched upon and the course is one of Forest Entomology, instead of Forest Zoology as it should be. The consequences are obvious. The student has only the most rudimentary notions of the position of the other occupants of the animal kingdom, if he is fortunate enough to possess any at all, or of that even of the Insecta themselves. He has been told a good deal about insects and yet would not be able to say where an insect came with reference to a coral, worm, snail, mussel, snake, fish, bird or mammal. That this is the case has been observable on many occasions. I would suggest a comparison of such a course with those delivered at the continental forest schools. We may turn to Dehra Dun. The students there, who will in future form the subordinates of the Cooper's Hill men, are given a course in *Forest Zoology*. A syllabus of this course has been prepared and a very short comparison with the lectures given at Cooper's Hill will prove without doubt the inadequacy of the latter.

At present the average student leaving Dehra Dun has a much better knowledge of, and is better equipped to help in the study of, Forest Zoology than the Assistant Conservator direct from Cooper's Hill. Special stress is laid upon this point for two reasons:—

1. It is becoming of the first importance that the Indian forest officer of the Controlling staff should have a good practical knowledge of forest Zoology and should realise that it is a necessary part of his training and essential in his field work.

2. It is of little use giving a good training to the Dehra Dun students if they find, on joining a division, that their divisional officer and his Cooper's Hill Assistant, owing to an inadequate training in the subject themselves, are unable to aid their Dehra Dun subordinates in the study of the animal pests in the forests in which they are stationed. Men whose knowledge of forest Zoology is confined to the meagre course at Cooper's Hill are unable to realise the importance of the subject or to understand the magnitude of the damage annually committed. It may therefore be suggested that, in the place of the present inadequate course at Cooper's Hill, one on forest Zoology should be substituted at the new training College for forest students. In the course of Forest Protection mention is made of the damage done by birds, rodents, etc.. in forests just as the lecturer alludes to the damage done by fungi in forests. In one case, however, the student has

already been told all about the fungi and their position in the Vegetable Kingdom by the Botany Professor and is thus able to understand the notes he is given on their action in the forest. In the other he loses the real significance of the points explained through not having been told the relation of the one animal to the other or of their real position in the kingdom.

The forest Zoological collections.—The transfer of the forest students from Cooper's Hill was, until recently, undecided; but even so the formation of a good forest Zoological collection was not impossible, and with this object in view some specimens of attacks on wood and bark by insects in Indian forests were brought back from India. During the recent tour in Germany Drs. Eckstein, Yakobi and Pauley at Eberswalde, Tharandt and Munich respectively have also promised to send collections of specimens. With these two sets to commence with it will be possible to form the nucleus of a good collection for the English students. In whatever manner they may be taught they will require this collection and such does not to my knowledge exist at present in the country.

PART III.

THE FOREST GARDENS AND SCHOOL INSTRUCTIONAL FORESTS.

As examples of the most typical Forest Gardens and School Instruction Forests seen or noted upon during the tour the Forest Garden at Tharandt and the School Forests at this place and at St. Petersburg may be described. Munich possesses school forests, whilst Eberswalde has forests in the neighbourhood which are used for this purpose. There are none such at Aschaffenberg or Nancy.

1. THARANDT.

An opportunity was afforded of visiting in company with the Director, Dr. Max Neumeister, the forest garden at Tharandt and the adjoining forests which are under his management and are treated entirely as areas for the instruction of the students. These areas are situated on two long hills, the town standing at one end of the valley, and on the plateaux above.

The Forest Garden.—The Forest Garden occupies the portion of the hill immediately behind the school. The hill side is terraced into beds which contain some 1,800 different species of trees, shrubs, perennials and annuals of various kinds. These are both indigenous and exotic. It is kept up as a forest and botanical instructional garden for professors and students and is one of the finest seen on the Continent.

In flat measurement it covers an area of 14 hectares. As it is entirely on a slope however, the true area is probably nearer 18 hectares. Each species has a prominent label placed in the ground in front of it or them, for the species are usually grown in clumps. The labels consist of a stout wooden peg to which is attached an elliptical porcelain plate (see fig. 23). The names are written on these in black block type. Latin and German names are given and the family and locality. There are also smaller porcelain labels fixed, about 10′ or so up, on the bark of the large trees so that the species may be always distinguished. Only the Latin name of the tree is given on these. As has been said, there are a large number of exotics present, the garden serving as a place of education in both botany and forest botany. In some parts wild flowers are allowed to grow naturally.

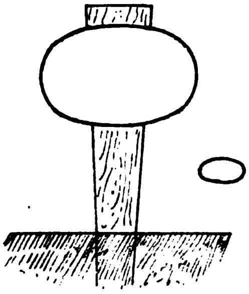
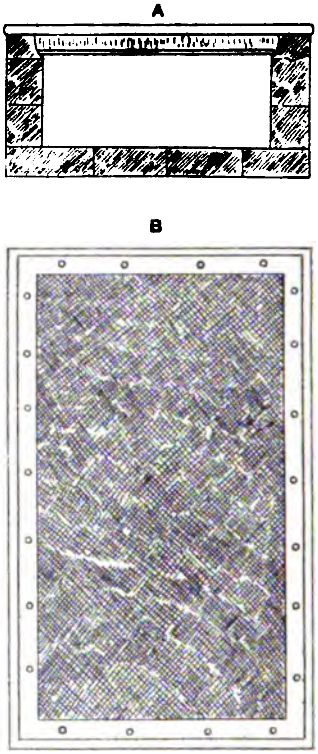


Fig. 23.



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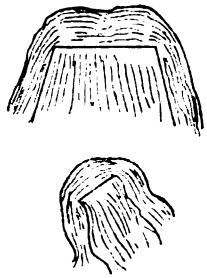

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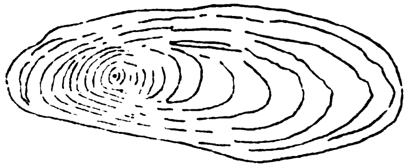

Fig. 26.

Fig. 23. Porcelain labels used in the Forest garden at Tharandt Forest Academy.
Fig. 24. A. Section of brick cell used for raising seedlings; B. Wire mesh cover (Tharandt Forest Garden).
Fig. 25. A poorly and well-grown branch (Tharandt Forest Museum).
Fig. 26. Development of a stem exposed to strong gales.

(to face page 33)

Photo.-Mechl. and Litho. Dept., Thomason College, Roorkee.

Zinco., February, 1906—No. 14[illegible]-10.

There is a nursery in the garden; the seed beds in this are placed in brick cells so as to secure entire immunity from the attacks of insect pests (see fig. 24). The bed is prepared as follows: At the bottom of a pit a layer of bricks is placed flatways. Two rows end on are placed on either side and end and in this coffin-shaped cell the prepared soil of the seed-bed is put, the seed sown and the whole covered with a wooden framework to which is fixed a fine wire mesh. This arrangement is expensive and these enclosed beds are chiefly used to raise exotic seedlings. Very few of those raised in this manner are lost. There are one or two glass houses in the garden. In one some curious grafting experiments were seen. *Picea ianensis* is successfully grafted on to ordinary spruce stems, 4-5-year old plants; a large number of plots containing these grafts in various stages of completeness were seen. Experiments have shown that it is not apparently possible to graft a spruce on to an Abies or *vice versâ.*

The Forest Wood Museum.—In the garden is a small wood museum consisting of one room about 35′ by 15′. The museum contains chiefly "sports," curious methods of growth, etc. There is a beautiful series of specimens showing how, if a branch is properly pruned it will heal completely over before the wood decays, thus demonstrating that the pruning of branches on large trees is possible without it resulting in decay commencing in the base of the branch pruned and going on down into the main stem. Fig. 25 shows a poor and well-pruned branch.

There is also a fine series of mistletoes showing the different methods of growth of the plant on different trees, *e.g.*, fine leaves and numerous, large and few, medium, berries, etc. There is also a very good example of the shape a stem takes when exposed to severe and continual gales all its life (*vide* fig. 26).

Fungi.—Some good examples of large fungi such as Trametes, Polyporus, Agaricus melleus on Fagus sylvatica, etc., are shown.

The School Instructional Forests.—These forests are kept up entirely for educational purposes. They consist of mixed woods and thus provide ever-varying conditions, aspects and problems to show to the student. In the possession of these forests, the forest garden and the fine forest college Tharandt may be said to be a model educational establishment. The forests contain spruce and beech with birch mixed or spruce and silver fir or the two latter with birch. Or again there are woods of spruce, beech, scotch pine, silver fir, larch, maple, birch with maple, ash (a little, 20 years old, planted by Neumeister himself), alder (in wet vallies), oak and a little *Aesculus*. There are some most interesting mixtures to be seen and they appear to do remarkably well.

The slopes of the hill sides down into the valley, which are steep, are worked differently to the table-lands above. On the latter they clear cut and naturally regenerate or sow and plant.

Exotics.—As at Friendwalde (Prussia, *vide* p. 46) exotics are being largely introduced and they annually send out from the forest garden and nurseries here thousands of plants into the forests all over Saxony. North American species are being introduced and the Douglas fir has been used here in planting up areas and is doing very well. An area planted with Douglas and Spruce was seen. The former were 2-3 times as high as the Spruce and were growing magnificently. They have some 42-year old trees 90′ high elsewhere in the forests. It is, perhaps, open to doubt whether, with this wonderful growth, the wood will be as good as that of the indigenous species.

Fencing of areas of young plants, protection of young plants by branches and protection of the bark of old trees (from being rubbed off by the horns of deer) by tying branch-wood round them as shown in fig. 27 are all largely practised. The King of Saxony is apparently a great sportsman and pays for all this so as to enable a large head of game to be kept in the forest. The high 7′ palings put round the areas of young plants cost half a mark per running metre. In spite of all the protection, however, the deer commit a great deal of damage. They are fed through the winter in the forests with hay and mangel worzels; fig. 28 shows the method of exposing the hay for the deer. It was noteworthy, as an instance of the fact that German forest officers are fully acquainted with their forest pests, that the Director pointed out the Larix Tinea larva and its attacks in these forests. The young caterpillars were defoliating the young Larix needles.

Of the educational value of the forests there can be little doubt and the beneficial results which accrue by treating them from this point of view and not from that of revenue-making solely are of very great value to the student.

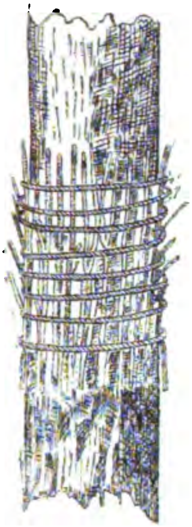

Fig. 27.

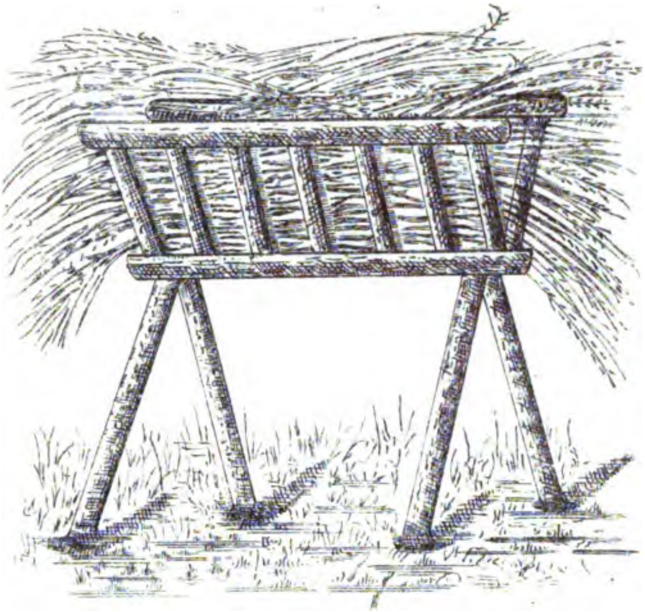

Fig. 28.

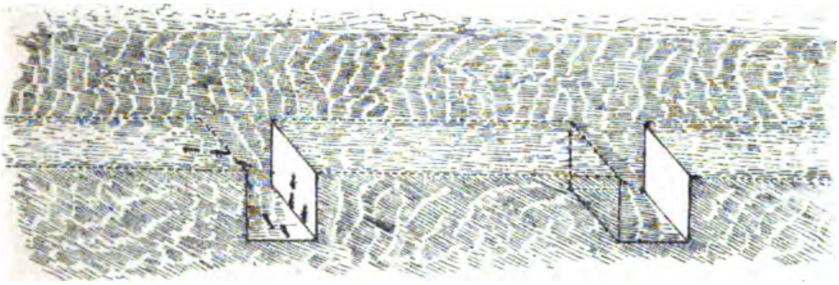

Fig. 29.

Fig. 27.—Protection of trunk to prevent the bark being rubbed off by deer (Tharandt School Forests).
Fig. 28.—Stand filled with hay used to feed the deer in winter (Tharandt School Forests).
Fig. 29.—Ditch and pits used for trapping *Hylobius abietis* (Eberswalde Scotch Pine Forests).

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Mechl. and Litho. Dept., Thomason College, Roorkee.

Zinco, February, 1906—No. 1425-11.

2. THE FOREST NURSERIES AT ASCHAFFENBURG.

There are two small nurseries both situated in a kind of large forest park belonging to the town. This park is in the charge of one of the local Forstmeisters.

The nurseries are quite small areas and are kept up as much for the instruction of the students as for any other purpose. The young plants are planted out in the forest park. Silver fir, larch, spruce, scotch pine, oak, beech, birch, maple, horsechestnut, elm, ash, etc., are amongst the species raised. Owing to the great abundance of the cockchafer pest (*vide* p. 42) the site of one of these nurseries had recently been moved. The change, however, has been of very little use.

3. THE SCHOOL INSTRUCTIONAL FORESTS OF RUSSIA.

There are two separate blocks of forest belonging to the St. Petersburg Institute. These are worked under the orders of the Director and are kept up solely for the instruction of the students, one being at a distance of 14 versts (about 9 miles) only from the Institute, the other about 60 versts (40 miles) away. At each buildings are kept up for the purpose of housing the Professors and students during their visits. When in the forest the students always work two and two together, never in bands; in this way the Director satisfies himself that each student actually performs himself every piece of work the system of tuition prescribes. Portions of each summer are spent in practical work in the forests, three months of the last summer of the course being passed in this way; this latter period is spent by the senior students in pairs in forests selected in rotation out of a total number of 150 set apart for this purpose; these forests were originally carefully chosen from the great forest areas of the country as affording special advantages for training purposes. The large number of 150 was selected so as to give the least amount of trouble to the managing staff, the latter of course not being under the Director of the Institute or in any way connected with it. As only 50 of these forests are visited in any one year the extra work and unavoidable inconvenience thrown upon the officers in charge only occurs once every three years. This arrangement would appear to be an excellent one and could be introduced perhaps, to some extent, with advantage at our British Institutions.

4. FRANCE.

The Botanical Garden at the Nancy Forest School.—The school stands in fine grounds and a large proportion of these are kept up as a botanical garden, areas being allowed to run wild in order to present a variety of wild flowers for the students.

Professor Henry has a number of experiments on hand. Some connected with an endeavour to ascertain the effect of the presence of different amounts of salt in the soil on the height growth of various young forest trees.

The Belle Fontaine Forest Nursery.—At Belle Fontaine, distant about four miles from Nancy, there is a forest nursery of old standing where both broad leaved and coniferous species are raised. Silver fir, douglas, spruce, scotch pine, larch, etc., were noticed, as also oak, beech, ash, hazel, maple, birch, hornbeam, etc. Owing to the formation of a pisciculture establishment here the fine nursery has to some extent suffered, many of the beds situated at the lowest levels on the sides of the stream having been broken up in order to form a small chain of ponds for the fish.

The instructional Forests attached to the Nancy School.—Formerly the Forêt de la Haye and the Forêt de Champenoux were attached to the school. These, owing to the short-sighted policy of a former Director who, not himself a forest officer, could not see the great advantages to a forest school which such areas confer, were made over to the general department. There are now only two small areas of about 400 hectares in la Haye and two in Champenoux reserved for the students, where they are allowed to mark trees for felling. Thus beyond being allowed to make a few markings in restricted areas the school has no forests under its own control. From the account of the advantages the Tharandt school forests confer it would appear that a mistake of considerable magnitude has been made at Nancy. This mistake is now fully realised by the staff and efforts are being made to get back the areas formerly belonging to the school.

PART IV.

ZOOLOGICAL INVESTIGATIONS IN THE FORESTS.

EBERSWALDE SCOTCH PINE FORESTS.

The scotch pine areas in the neighbourhood of Eberswalde were visited in company with Dr. Karl Eckstein in order to inspect the methods in force for combating insect and other animal attacks.

Insects.—The chief insect pests here are the Chafer, *Melolontha vulgaris* and the weevil, *Hylobius abietis*. The spruce and larch chermes, *C. abietis laricis*, is also present on these trees, whilst there is a second chermes infesting *Abies pectinata*. This latter insect has committed a certain amount of damage and methods are being experimented with for its extermination.

Method of combating the attacks of Melolontha vulgaris.—The life-history of this pest is well known. The beetle here feeds upon the leaves of the Birch (Betula); the grubs on the roots of the scotch pine (the chief tree). Elsewhere the latter eat all sorts of other roots both of coniferous and broad-leaved species, apples, pears, etc. One of the means of getting rid of the insect is to plant lines of young birch trees in the young plantations (or sow seed here and there) or in the blocks which have been sown up with scotch pine seed. The beetles will collect on the betula leaves in May (when they make their first appearance in the year) previous to laying their eggs and are easily collected by women and children and killed off before ovipositing. Unless taken at this period the beetles lay the eggs in the soft soil in the compartment containing young trees, the grubs on hatching, feeding upon the roots. The operations of these latter cause blanks which have to be filled up by planting in young transplants at extra cost.

Hylobius abietis.—This weevil is a serious pest in this part of Prussia. The beetles hibernate in the humus in the forest during the winter, marching out into newly planted up areas in the spring to feed upon the young plants. The grub does no harm; it feeds in the bark and sap wood of felled trees or in the roots of such. The damage is entirely done by the beetle feeding upon the sap of the young plants. It also sucks up the sap oozing from wounds on older trees. Advantage is taken of this latter fact to trap it in the following ways:—

(i) A narrow trench, 1′ × 1′ with straight sides is dug all round the area which is to be, or has been, sown up. On the outer side of the trench is the forest. In the spring the beetles issuing from this latter fall into the trench. At the bottom of this square pits are dug at intervals of 10-20 metres and the beetles, turning to right and left after falling into the trench, drop still further down into the pits (see fig 29 p. 35). These latter are visited every three, five, or ten days and the beetles taken out and killed. The trenches are kept clean for the first three years, being cleaned out the fourth and fifth year after the new ones of those years have been dug.

(ii) Bark traps—A 2′ 6″ length of a scotch pine stem with a diameter of about a foot is split down longitudinally. The bark of one of the halves is sliced down in two or three places so as to expose the cambium layer from which the sap slowly oozes. The section is then placed bark downwards in a shallow trench, being raised off the ground on either side. The trench is made of just sufficient size to take the stem section comfortably (see fig. 30). This arrangement serves as a trap, the beetles visiting the bark to feed on the sap. These traps are placed amongst the young plants at about 20 yards apart. They are also placed on the outerside of the ditch along the edge of the forest. They are visited every three, five, or ten days. Eckstein is introducing a scheme by which they will be visited every day over a certain area in order to see whether better results will not be obtained in this way. The split log is not always placed in a pit; it may be simply laid flat on the ground amongst the heather or other plant growth (fig. 31): *e.g.*, pits would not be made in hilly country. Squares of bark (fig. 32) are often used instead of the logs. Two or three strips being placed one on the top of the other and weighted down with a stone.

Hylesinus piniperda and Tomicus lineata.—These are the two chief scolytids attacking the scotch pine here.

Method of distinguishing their attacks from the outside of tree.—The beetles both attack the tree at the same time and towards the end of April are to be found egg-laying. Some felled pine trees were examined and the bark showed numerous holes where the beetles had bored in. At the mouth of the holes and on the bark below them were the usual small masses of saw-dust ejected by the boring beetles from the holes. In the case of the Hylesinus this was red-brown owing to the beetle boring into and up in the bark only to make its egg chamber, whereas in the case of the Tomicus the saw-dust was white owing to

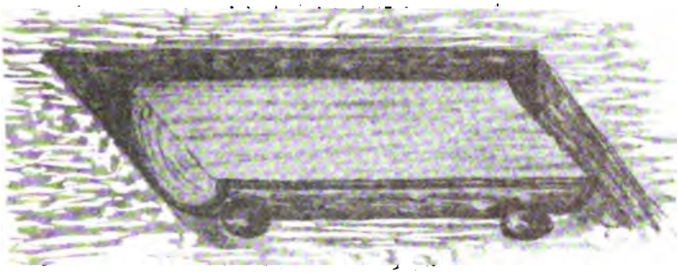

Fig. 30.

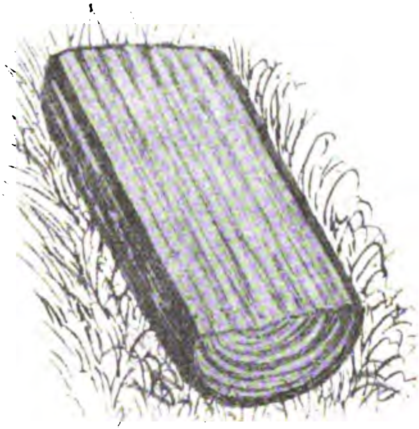

Fig. 31.

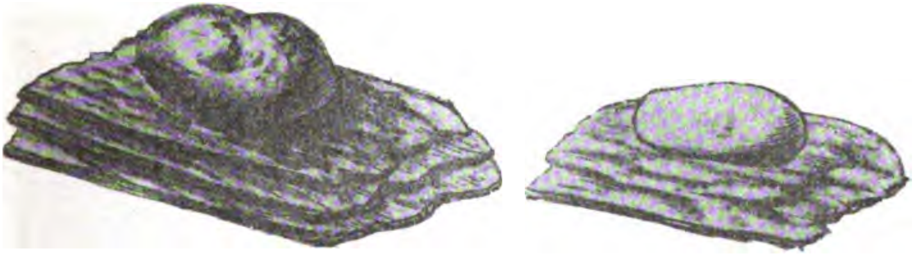

Fig. 32.

Figs. 30-32. Bark traps to catch *Hylobius abietis* (Eberswalde Scotch Pine Forests).

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Photo.-Mechl. and Litho. Dept., Thomason College, Roorkee.

the beetle boring straight down to the sap wood and making its egg gallery in this.

Methods of prevention.—The plan is followed of felling green living trees at the beginning of the season, about the end of March, to serve as traps for the beetles. The latter seek these for ovipositing. All the trap trees are barked between the 1st and 15th of May by which time the beetles will have finished ovipositing and the eggs will have hatched out into larvæ. The barking of the trees will kill off all these grubs, which on exposure to the air and sun soon die.

Insect Protection in the Forests.—If there is reason to believe that a particular defoliating pest may become numerous in the following year 10, 20 or more trees per hectare are selected and in November and December the top layer of moss and humus for a metre distance from the foot of tree is removed all round as shown in fig. 33. All cocoons and larvæ found beneath are taken out and killed. By the number present an estimate can be arrived at as to whether it is advisable to treat more trees in this way. The Furster (ranger) is responsible for this work and must send in yearly a report on it. He has to keep an eye on the dangerous pests and be able to say whether any of them have been or are numerous in any particular wood during the year. He is responsible that reports on this subject are made out and sent by him to the Oberfurster The latter on receiving the report sends it on to the Oberforstmeister and the latter is able to give orders as to what is to be done to meet the attacks. Should these latter involve a large outlay of money for protective works he must report to the Central Government to obtain sanction to the expenditure.

Tar Rings.—These are only used against *Lasiocampa pini.* There was an attack of this moth in the Spruce forests 20 years ago, but the insect is now somewhat scarce in these forests. The tar ring is painted on to the trees in order to prevent the caterpillars crawling up the bole to get into the crown. It is made of a composition,* being 3 m.m. thick and 3·4 c.m. broad. Even if the caterpillar succeeds in crossing it the long hairs which cover its body get covered with the composition and it soon drops back on to the ground. Before the ring is painted on the bark is shaved off as shown in fig. 34 so as to leave a smooth surface. This is to ensure the ring forming a complete band round the bole without interruption by interstices up which the larvæ could crawl. In the case of very bad attacks two rings are placed on each tree with an interval between them.

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* The composition of this 'patent' tar is supposed to be a secret but several German firms sell it at about 7s. per cwt. at the factory. It consists chiefly of wood-tar, resin, wood-vinegar, various oily ingredients and probably black soap. It must possess the properties of not congealing with late frosts, of remaining semi-viscous for over three months and of not running with heat; the second proviso is a most important one.

Protection of seedlings.—To protect the young seedlings from the attacks of birds the seed is painted red before sowing. Red lead is used, 2 lbs. of the latter being sufficient to paint 14 lbs. of seed. When the young seedling pushes its way up above ground the cotyledons are at first covered by the outer covering of the seed (see fig. 35). This covering having been painted red acts as a deterrent to birds by frightening them.

Attacks of Deer.—Both the red deer and the roebuck are present in these forests and commit a considerable amount of damage amongst young trees, more especially to coniferous species in the winter months when the ground is covered with snow, and they have to depend upon evergreens for sustenance. Owing to these attacks areas which have been sown up and in which the young plants have come up well will develop blanks which have to be filled by transplants at extra cost. In order to protect the young plants the needles of the *leader only* of each are tarred. The deer eat the side shoots but will leave the leader untouched owing to the presence of the obnoxious tar. Care should be taken to see that only the *needles* and not the terminal bud or any buds on the leader are tarred.

The fisheries.—These were inspected with Dr. Eckstein. The Zoological Professor is also in charge of the fishery work in Germany. Eckstein is breeding and rearing young trout and making observations on the young stages of growth. He has a series of ponds in the forest for this purpose. They are not as good as they should be as the stream flowing through them is a mere trickle. He feeds the youngsters after hatching on pancreas which is made into a fine paste or jelly and smeared on to the lower half of wooden balls which float on the surface of the water and thus enable the young fish to feed on the stuff. The ova are hatched out in an underground room of the forest guard's house in small covered pans or wooden troughs painted black and with a lid painted black inside so as to represent the conditions of the stream, the fish in their natural habitat always lying in dark places.

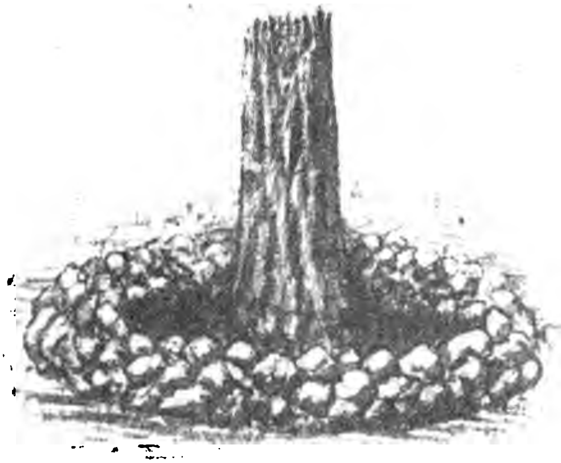

Fig. 33.

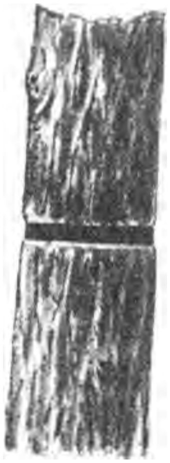

Fig. 34.

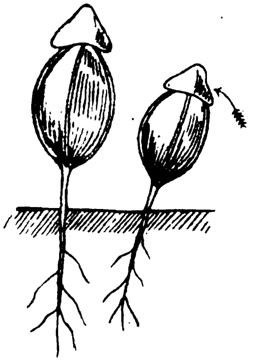

Fig. 35.

Fig. 33. Showing method of searching for noxious insects (grubs, pupæ, &c.), by removing the top layer of moss and humous round the base of the tree (Eberswalde Scotch Pine Forests).

Fig. 34. Tar ring placed on tree to prevent the ascent of the larvæ of *Lasiocampa pini*.

Fig. 35. Cotyledon covering painted with red lead (whilst in seed stage) to prevent attacks of birds (Eberswalde Scotch Pine Forests).

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Photo.-Mechl. and Litho. Dept., Thomason College, Roorkee.

Water continually flows into these pans from a small stream allowed to run through a series of pipes from outside. When they are old enough the young fish are put out into a series of ponds and lakelets kept separate from one another and provided with an ingenious device of the Professor's which both prevents the young fish leaving the pond and also prevents them getting smashed at the overflow by the strength of the current. It consists merely of an iron gauze mesh box in the shape of a parallelogram (see fig. 36, p. 51) which is placed with its long axis facing up stream at the overflow. The water thus pours out through this not only at its upper end but also through the sides and top the pressure being thereby distributed and thus lessened. The mesh of the box is too small to allow the trout to pass through. The fish are reared in the ponds. They are fed all through spring, summer and autumn. Use is now to be made of the *Melolontha vulgaris* which is very common and destructive here. The beetles are caught and paid for at a few phenigs per thousand. It is proposed to make them into a paste by drying and grinding them up and using them to feed the young trout after they have passed the pancreas stage. The Doctor has some fish now about 10" long. His experiments are but just beginning, the above being the gist of them to date. A small laboratory has been built adjacent to the ponds in which to carry on the experiments and microscopic work.

FRIENWALDE FORESTS, PRUSSIA.

The damage done by insects is of considerable importance in these forests, heavy loss being occasionally incurred. One of the commonest pests is the wood-boring beetle *Cerambyx heros* which tunnels into and ruins oak timber, the latter as a result of these attacks becoming useless for timber purposes thus entailing a heavy pecuniary loss. Logs with a two-foot diameter were seen with holes right through their middle.

The scotch pine wood are infested with *Hylesinus piniperda* and *H. minor.* The former is very plentiful and has caused a very considerable amount of damage. The latter is by no means so plentiful. Specimens of each were taken towards the end of April.

The fungus Nectria ditissima is very plentiful on the beech trees, the attack causing large open wounds at the base of the tree. All infected trees are cut out wherever possible, this being the only known practical remedy.

THE FOREST PARK AT ASCHAFFENBERG.

The chafer beetle (*Melolontha vulgaris*) so plentiful in the Eberswalde forests was swarming here in the middle of May, their dead bodies strewing the paths of the park in great masses. They commit an immense amount of injury here. Hylobius abietis is also very common in these forests.

The Nun Moth (*Liparis monacha*).

Note i.—Whilst at Rohrbrun in Bavaria the following interesting information was given me on this insect. The Forstmeister during his service had had considerable experience of this pest. In the 1891—1893 attack 10,000 hectares were stripped bare. They had to cut the trees down as a direct result of this attack. The parasites *Ichnenmon circumflexa* and *Tachinus* made their appearance in the second year. The Forstmeister put 100 of the moth larvæ in a box. They all pupated. Only 9 moths issued from the pupæ. Of the rest 30 were ichneumons and 60 tachinds—1 remaining unaccounted for. This is a most interesting experiment as serving to show the proportion of ichneumons to tachind flies present in the forest.

Note ii.—Attacks of the Nun moth in Austrian forests between years 1888—1898.

The Austrian Government have had drawn up and issued a large map showing by differently coloured patches the destruction committed by the Nun in Austrian Forests during the ten years, 1888—1898. From 'slight' to 'total' destruction and 'intermediate' stages are represented by different colours. Figures of area are shown for the following provinces: Bohemia, Galicia, Moravia, Basse Autriche, Haute Autriche, Silesia and Tyrol.

The total amount spent in combating the pest works out to a sum of 637,620 florins for the ten years. A most interesting monograph has been compiled for the whole period.

2. FRANCE.

The Gérardmer Forests in the Vosges.

(*a*) *An invasion of Scolytidæ.*—The Gérardmer forests form the Spruce and beech region of the Vosges with a certain proportion of Silver fir. On February 1st, 1903, they were visited by a severe hurricane which blew down in a few hours 1,233,283 cubic metres of coniferous trees in the crown and communal forests. The disorder and ruin caused by this storm were immense and resulted in a large amount of dying and broken unhealthy trees remaining in the forest through that year. This has led, as might have been surmised, to a severe invasion of Scolytidæ or rather to a great increase in their numbers. The beetles present are *Tomicus typographus* which confines itself to the Spruce, and *T. curvidens* in far less numbers in the Silver fir. The coming attack was not noticed before the second week in October 1903 when infested trees were marked down in the communal forest of Gérardmer. These trees were at once cut out, barked, and the bark burnt. In the spring of 1904 the Forest Officer of Gérardmer reported having seen large flights of Scolytidæ in the neighbourhood of the lake and the real seriousness of the position was then realized. The writer visited these particular forests at the beginning of June in company with Prof. Henry and was thus able to make a personal examination of the attack. A number of trap trees had been felled and these in the case of the spruce were swarming with *T. typographus* as were also standing trees inspected. From observations made the attack has all the appearance of being a most serious one and its development will be watched with considerable interest. The instructions issued are:—

(1) Search for all infested trees.
(2) As soon as found fell them, cut off the branches and bark the stems.
(3) Burn the whole of the branch wood and throw into the fire all the bark of the trunks. This bark and the branches being full of the larval, pupal and immature beetle stages of the insect, the whole of these will be killed off.

Unfortunately for the success of the operations against the beetles the present year 1904 is a phenomenally dry and almost tropical one and will probably lead to the beetles passing through two generations, instead of the usual one, in the year with a corresponding large increase in their numbers.*

T. curvidens which is appearing in unusual numbers in the Silver fir is not regarded with the same fear as its confrère of the spruce.

(*b*) *Orestes fagi* (Curculionidæ) is appearing in unusual numbers on the beech this year. All the stunted beech near the crest of the Vosges are badly attacked by this insect.

(*c*) *Fungi in the Vosges.*—The witches broom, *Nectria ditinima,* is the most serious. In places it is very abundant on Silver fir, especially in pure forests. In connection with this latter statement one of the Forest officers here mentioned to Mons. Henry that he had observed a place where the fungus was very plentiful on the spruce on one side of a road whilst those (the forest is pure spruce) on the other side were completely free. This observation requires investigation and explanation. The only remedy for this disease is to cut out badly infested trees and this is done without hesitation when the pest appears to any serious extent.

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* For further information upon this attack, *vide* my note 'An invasion of Scolytidæ in the Vosges' *Indian Forester* XXXI, 395 (1905).

Buprestid Pests in France.—There are two chief buprestid beetles which commit serious damage in France. The first *Coraebus fasciatus* was originally confined to *Quercus ilex*. It has now spread to all the oaks and commits a serious amount of damage. The second is *Coraebus endatus* which infests, at times to a great extent, *Quercus suber*, the cork tree of south-western Europe.

The Belle Fontaine Pisciculture Establishment.

At Belle Fontaine, distant about 4 miles from Nancy, there is a forest nursery and pisciculture establishment. The pisciculture establishment is a new departure and the French are apparently following in the steps of the Germans in this respect. The idea is (i) to study the ailments to which young fish are liable : (ii) to introduce new species and varieties of larger size and value into the rivers and streams. The establishment here is on the same lines, though on a larger scale, as that seen at Eberswalde. The fish are reared from the egg in small flat cisterns supplied with a continuous stream of running water. As soon as they require it, *i.e.*, a month after hatching, the young fish are supplied with food and they are not put out until they are a year old. From observations made at the time and others pointed out it appears probable that the fish are kept too long. A fish reared for a year and then put out into a stream would not have much chance against the rapacity of its own kind. Old trout are great cannibals. From experiments made it is also likely to prove a fact that the hand-reared fish are of much smaller size at the end of the year than their fellows of the same age living under natural conditions. It stands to reason that a fish fed for the first year of its life would be a very different creature at the end of this period to his wild stream-reared brother and that, when placed under similar conditions, he would find considerable difficulty in procuring food and protecting himself.

The pisciculture business has been taken up so keenly by the Government that the fine nursery here is to some extent suffering, many of the old beds having been broken up to prepare artificial lagoons and lakelets for the fish to be put out into.

PART V.

NOTES ON SOME FORESTS SEEN DURING THE TOUR.

1. THE EBERSWALDE SCOTCH PINE FORESTS, PRUSSIA.

In an interview with the Director of the Academy, Herr Oberforstmeister Riebel, a considerable amount of information was obtained about the Eberswalde forests and a tour or two of inspection was made in company with Dr. Eckstein.

The soil is a very sandy one round Eberswalde and Scotch Pine may be said to be the principal species. There is some birch and a little silver fir, spruce and larch. The Scotch Pine is treated on a rotation of 120 years, the system being to clear cut, leaving a few standards to act as mother trees, and obtain natural regeneration. Failing this the areas are sown up and gaps, due to the death of young trees, are subsequently filled by others being planted in.

It was of interest to hear that the chief markets of these forests were Liége and England, the wood being in demand for the coal mines of these localities. Every cubic foot of this timber could be grown at home and the Germans here expressed themselves as quite unable to understand our apathy in this direction.

2. FORESTS ROUND FRIENWALDE, PRUSSIA.

These forests occupy low hills and may be said to consist of several distinct classes of growth.

(*a*) *The Oak and Beech Forests.*—These are not as good as those of the Spessart taken as a whole, but they contain here and there small areas of oak, and especially in one case, of young oak naturally regenerated, which rival even the Spessart. The piece of young oak alluded to was 8—10 years old and was as good as could be required. The rotation for the oak is 200—250 years, that of the beech 200 years. The value of oak is from 80—100 or even to 150 marks per cubic metre.

The most valuable tree in the forest here is of course the oak. In the best piece of forest they have 75 per cent. oak to 25 per cent. beech. The annual fellings in the oak areas depend upon the seeding. In a good seeding year they cut half the trees over the area. To regulate the annual amount cut and income they keep back that year other cuttings which would have been made. Areas to be regenerated are fenced all round at a cost of half a mark per running metre to keep out pigs, deer and hares which commit serious depredations in these forests. The fence is about 8 feet in height. The surface is raked over previous to the dropping of acorns. When the oak regeneration is complete and young plants up the surface is again raked over as soon as a good beech mast is seen to be on the trees. The fencing against animals is costly but necessary. It has to be kept up until the area of young growth is out of danger.

(*b*) *Pure Beech forest.*—This is found on areas where the beech was allowed to get the upper hand, owing to the oak mast failing, and occupy all the ground. These areas are now being underplanted with larch. The larch will be removed either with the beech or when from 70 to 100 years old.

(*c*) *Scotch Pine.*—This is preferred to the beech here as the wood is of greater value; stems of 10 metres by 48 c.m. are sold at 25—27 marks, 6 m. by 25 c.m. for 12 marks. The rotation as in the Eberswalde forests is 120 years.

(*d*) *Exotics.*—These are being introduced on a very large scale in these forests with the idea of growing the wood now imported from America. Many of the species seen grow with great vigor and in this way contrast most favourably with the indigenous ones. One cannot help wondering however whether the wood from these quick-growing trees will be as good in quality as that of the trees imported from their natural habitat; *e.g.*, I saw a young plantation of *Quercus rubra* and *Q. Americana* planted in lines as an experiment. The *Americana* were half as large again as the *rubra.*

The exotics are being largely planted out in the forest in circular clumps, the species in the clump being either pure or mixed. The trees are principally North American and Japanese species. The following are those which they think may do well in high forest in this locality:—

> Pseudotsuga Douglasii, Picea Sitkaensis, Pinus strobus, Chamaciparis lawsoniana, Thuja mezinsa, Quercus rubra, Robinia pseud-acacia, Careya alba, Juglans nigra, all from North America; Larix leptolepis from Japan.

They import from North America Pinus palustris, and P. australis, Juglans nigra and Careya alba. This introduction of exotics is a most interesting experiment to watch. The Forstmeister in charge here is very confident of success.

3. NOTES ON FORESTS SEEN BETWEEN WIRBALLEN AND ST. PETERSBURG WITH SOME DETAILS ON THEM FURNISHED BY MR. KERN, DIRECTOR, IMPERIAL FOREST INSTITUTE.

For forest purposes Russia may be said to consist of three areas. The north and north-east where the finest forests are situated, the north-west and west where the forest is of a poorer quality, and the south where the greater amount of cultivated land is to be found.

In the north-west, after leaving the German frontier at Wirballen, the patches of oak and beech forest become rarer and rarer, the country is flat and soon has a wild dreary look. The forest-clad patches become larger again as we proceed East and when they disappear give place to wild moors and heather, much larger and wilder than anything existing in England. A little cultivation appears here and there with small villages, the houses with thatched roofs and wooden walls often in a very dilapidated state. The forest, when the oak and beech disappear or nearly so, consists of Scotch pine and spruce with perhaps some scattered oak and beech; or the trees may consist of Scotch pine and birch, the latter tree not growing as we know it in England, tapering and dapper. Here it develops into a great thick straight-boled forest tree keeping its crown on a level with those of the Scotch pine. It is to be seen growing pure at times, the reason being, according to my informant, Mons. Kern, that the system worked on is to fell an area completely and allow it to seed itself up naturally with birch seedlings. After a time Scotch pine and spruce will come in naturally beneath the birch and when these latter have developed to a certain extent the birch is cut out. The rotation for the Scotch pine and spruce is from 100—120 years. When the forest is mature it is felled *en bloc* and the process repeated.

The engines on the Wirballen-St. Petersburg line burn fuel entirely, and at depôts along the track great stacks of the same are to be seen. The stacks consist of several kinds of wood, but perhaps Scotch pine, spruce and birch prodominate with beech and oak in lesser amounts. Silver fir is also present. Also Larch and this tree is to be seen in the Scotch Pine and spruce forests, The railway line in north-east Germany is fenced on either side with great wooden palings. These consist of stout uprights with 5 or 6 planks (deep) nailed to them. They are here to prevent snow drifting on to the line, especially in cuttings. In places these palings are replaced by a good stout topped spruce hedge from 6′—8′ high, the trees planted 3—4 abreast. The policy appears now to be to replace the palings on a large scale by the spruce hedges, as miles of small ones, the plants 4—6 years old and even younger, are to be seen.

The country evidently depends a great deal upon its forests. The poor dilapidated cottages of the villagers are entirely made of forest products, in this way resembling those of the inhabitants of India in forest tracts. In fact they look much like village huts in parts of India. As has been stated the railway requires fuel and also obtains its sleepers from the forests. The railway stations (except the ones at the very few large towns one passes) are all built on one plan and of wood. Heavy chalet-like buildings with zinc roof painted red, the wood all painted ochre colour. Besides the station building there are the quarters of the staff close by and railings, etc., all of wood.

Cutting.—The felling of trees appears to be done very carelessly. In areas where thinnings have taken place stumps are to be seen sticking up in all directions and an area where a clear felling has taken place looks exactly like a piece of forest land newly cleared by villagers in India for cultivation. Felling is however said to be carried out on more scientific lines in the larger and more valuable forests, and it is possible that the areas here alluded to may not have been State forests.

Round Wilna, which is situated in a dip amongst undulating hills, I noticed some oak forests, the trees not of great size. After leaving Wilna one passes through miles of wild waste land on which young Scotch pine and birch trees are to be seen coming up. This country alternates with thick patches of Scotch pine, spruce and Silver fir forest with birch. To see these wild moors being brought under forest shows what could be done in this respect in England, were we to take our common lands and moors in hand. Mine props, deal planks, etc., could be all or in large part grown at Home by the outlay of a small capital.

It was noted that the rivers passed were used to float down the produce, both in the round and also converted as sleepers, planks, beams, etc., the material being formed into rafts.

The forest roads in Northern Russia, of which a number were seen from the train, were apparently mere mud tracks. M. Kern stated that they do better than this in their more valuable forests. The roads are probably not of high class, however, since the roads in St. Petersburg itself are a disgrace to the capital and would be quite impossible in the smallest country town in England. In the suburbs they are worse, the footway for passengers consisting of a couple, or even of a single plank, and mud.

The boundary marks on the forest boundaries consist either of stone pillars, wooden posts, wooden posts surrounded by mounds of stones or earth, or merely earthen mounds or heaps of stones.

Exports.—The products from the forests of this part of Russia are exported from Riga which as far as the value of this class of export is concerned occupies the first place among Russian ports. The value of the exports in the years 1896—1898 increased from 11,500,000 to 14,500,000 roubles. The exports from here are chiefly planks and beams, squares and mine props, 3,000,000 of the latter being sent abroad, the greater portion to Great Britain. The pine wood exported from Riga is known in the trade as "Riga pine" owing to its excellence.

St. Petersburg and Cronstadt come next in the value of their forest exports, the sum amounting to between 8 and 10 million roubles, the material exported being chiefly planks. Sixty per cent. of the exports from the ports go to Great Britain, being landed at the ports of London and Hull.

The forest products sent across Russia's continental frontiers are chiefly taken by Germany through which flow the lower portions of the Rivers Niemen and Vistula. About 10,000,000 roubles worth of forest produce are annually transported by these rivers into Germany.

In answer to enquiries instituted at the Forest Branch of the Ministry of Agriculture in St. Petersburg considerable information of interest on the Russian forests was very courteously furnished me. It is possible that an article on these forests for publication in the *Indian Forester* may be written at a later date.

4. ROHRBRUN FORESTS, SPESSART.

The Director of the Aschaffenburg Forest Academy, Dr. Von Furst, very kindly arranged an excursion to the nearest forests in the Spessart where some of the finest oak and beech in Germany are to be seen. Two of the Cooper's Hill students happened to be going through to Rohrbrun and the journey was made in their company.

Some hours were devoted to the oak and beech forests round Rohrbrun in company with the Forstmeister and the Cooper's Hill students.

These forests are of considerable interest to the Forester for two reasons—

(*a*) They contain some of the show forests of Germany.

(*b*) The areas are subject to heavy "litter" rights, the inhabitants of the surrounding villages having the power to remove a certain amount of humus or top litter from off the soil. This is perhaps one of the most pernicious rights to which a forest can be subject and its bad effects are to be seen here in the impoverished character of the soil.

Other rights are to green branchwood of under 5 c.m. diameter; to standing dead wood of under 9 c.m. girth, to root stocks and to all wood of under 1 meter in length and to all wind-fall trees provided there is not another one within 150 metres. This latter proviso is to provide against the right including areas of trees blown down in storms, etc. It is needless to say that these rights considerably affect the treatment and up-keep of the forests and the revenue obtained from them. Their study is of considerable interest to the Indian forest officer who often finds himself confronted in India with many varied and complicated rights over and in his forest areas.

In the management of the forests oak is the most valuable species and the one to which most attention is paid. In regenerating areas the beech is first cut out. The natural regeneration of beech is invariably very good and thick. In the first year the beech seedlings are removed with a rake. In the following year all found are pulled out with the hand to make room for the oak. Subsequent to this for eight years or so the beech seedlings are cut back so that they shall not interfere with the young oak. After the ten years the beech is allowed to grow and a mixed oak and beech forest results. The oak seed (acorns) is sown in trenches placed in parallel lines.

The rotation of oak is	300—350 years.
Ditto beech	120—150 „

Two or three rotations of beech may be passed through to one of the oak. The beech is allowed to come in under the oak say of 100 years

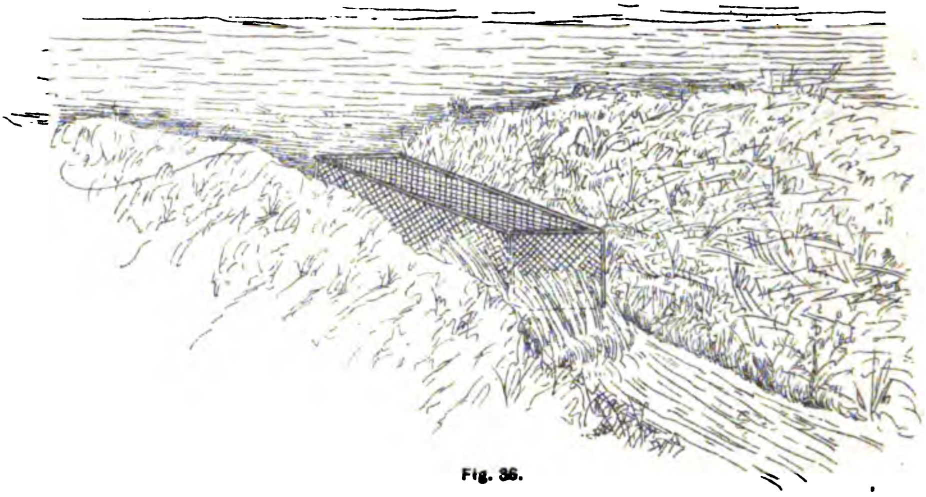

Fig. 36.

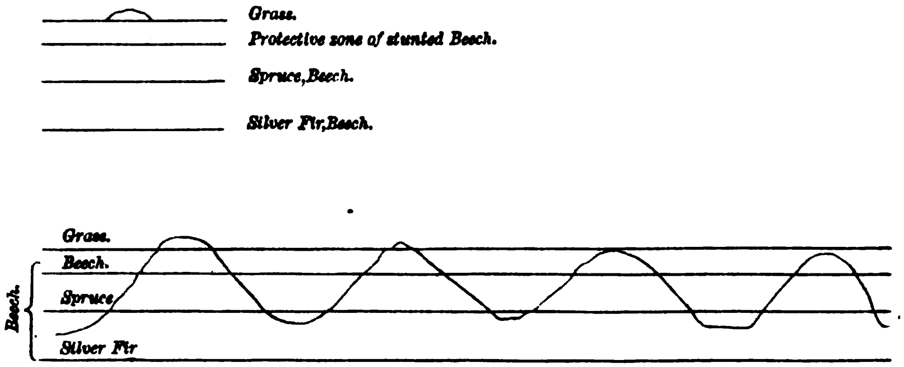

Fig. 37.

Fig. 36. Gauze mesh box used to prevent young trout escaping from lake with the overflow of water (Eberswalde Pisciculture Establishment).

Fig. 37. Diagrammatic Section showing distribution of the trees in the Forests of the Vosges (France).

(to face page 51)

Photo.-Mechl. and Litho. Dept., Thomason College, Roorkee.

Zinco., February, 1906.—No. 1425-12.-250.

in which a thinning has been made to remove all dead, diseased and badly shaped trees. At 120 years of age the beech wood is cut over and another young wood allowed to take its place.

5. THE FORESTS IN THE VOSGES.

Through the kindness of M. Guyot, the Director of the Nancy Forest School, and of M. Henry it was possible to make a short tour in the Vosges in company with the latter and the senior forest students at the school. The object in undertaking the tour was three-fold—

(i) To observe M. Henry's method of conducting his tours for practical work.

(ii) To inspect any methods of combating insect attacks in the forests we might come across.

(iii) To see something of the forests in this hilly region.

The tour made occupied several days. Leaving Nancy we proceeded to Raon-l'Etape which is at the Porte-des-Vosges. From here we went to Gérardmer making excursions from the latter place into the neighbouring forests and to the top of the Vosges at a spot known as the Schlucht. During this latter excursion we had an opportunity of inspecting the changes in the character of the growth at various elevations, the forest being replaced by green grassy mounds at the summit of the hill tops, *vide* the diagramatic section in fig. 37.

Raon-l'Etape Forests.

Situated in the lower hills of the Vosges on a sandy soil.

The forest is either mixed silver fir and beech or pure silver fir. The regeneration is all natural. No planting is done or at the most it is only the transference of young trees from an area of dense natural regeneration to one in which the growth is thin.

The aim is now to obtain mixed beech and silver. Formerly they waged war against the beech and practically exterminated it. It is now seen that this policy was a mistake and the species is encouraged. The forests here form the lowest stage of the diagramatic section (fig. 37). The reason against the formation of pure silver fir woods is that in these the attacks of the Witches broom (Nectria ditissima) fungus are always very severe. Insects (Scolytidæ) are also much more dangerous in the pure forests.

Amongst the many subjects which he lectures upon M. Henry includes that of Geology and the students were shown a sand-stone quarry as also a large trap rock quarry here. From this latter the paving stones used in Paris and other large towns in France and for the metalling of all the great public roads are extracted.

Paper Mills.—We were also shown a most instructive paper mill. The owner possesses large forests of his own and uses all the wood from his annual cuttings in this mill. In addition he also purchases large amounts. The whole of the methods by which the blocks of wood seen in one room are finally produced as a high quality paper at the end of the processes was first inspected and afterwards it was possible to see the uses to which the paper is put. The works include printing presses, photogravure presses and ordinary process block ones. The whole of the machines were in full work and it was possible to inspect serial numbers on art subjects, volumes full of artistic photogravures, etc., the whole printed on paper made from the wood lately stacked outside the building—ordinary spruce, silver fir and Scotch pine. The Western Himalayan forests are full of the first two species and it should prove possible in the near future to erect paper mills in suitable spots to make use of this at present scarcely utilizable timber.

Gérardmer Forests.

This place is situated at about 18 kilometres from the crest of the Vosges at the Schlucht along which runs the French and German boundary.

At Gérardmer we were in the spruce and beech regions of the Vosges, the 2nd on the diagramatic section. From here in climbing up to the Schlucht the almost pure spruce gives place to beech and spruce and finally the latter disappears altogether and at about 3,000 feet only beech remains. Above this elevation the beech, though forming a fairly dense growth, acquires all the characters of a tree which has reached tree limit and becomes very stunted, the crowns being flat and ill-formed owing to the influence of winds and snow. Above about 3,500 feet the beech which is accompanied by a little sycamore, ***Sorbus domestica*** (?) and ***Sorbus aria*** disappears, being replaced by short turf amongst which wild pansies, ranunculus, anemone, and the usual mountain top flowers are to be found.

There is a higher crest than the Schlucht called the Hof Nek, elevation nearly 4,000 feet. From here the highest point in the Vosges called the Guebwiller, elevation 4,300 feet, can be distinctly seen.

Tree growth in Vosges.

To summarise.—In the lower hills there are silver fir forests on sandstone with scattered spruce only. With the silver fir is the beech which for over 100 years it was the policy to cut out and exterminate; mixed silver and beech is now the aim. Higher up the spruce replaces the silver fir either pure or mixed with beech, and gradually as the elevation increases the spruce disappears and beech with a few species such as sycamore, sorbus, etc., clothes the upper slopes as a stunted forest. Finally all tree growth disappears and we reach the crest consisting of a rounded dome of turf. These rounded dome-shaped crests are very characteristic of the Vosges.

Management.—In the upper slopes jardinage is practised, the forests being kept chiefly for protective and climatic purposes. Lower down in submontane tracts the treatment is by a series of seeding fellings. Natural regeneration is always depended upon and in this and in the length of the rotation the French differ essentially from the Germans; the former believe in retaining the tree for a long time as the larger the timber the greater its value; the Germans on the other hand prefer the short rotations and thus turn over their capital more rapidly.

Hill Pastures.—The proportion of the hill pasture land is very high in the Vosges. There are in all 200,000 hectares of meadow land, the proportion to cultivated land being in the ratio of 1 to 2½.

Growth of Spruce and Silver Fir.—Some very fine trees of each species were seen the silver fir being considered to be at its best in the Vosges; the limit appears to be about 44 met. in height and 1 m. 15 cm. in diameter.

Revenue.—The forests of the Vosges yield from 100 to 125 fr. per hectare per annum; thus in France only the Jura forests can vie with the Vosges in value.

The Vosges form a fine example of the various ways of utilizing the soil. Where possible the land is under field cultivation; if not good enough for this purpose it is used as meadow land and the remaining area is under forest from which a very good return is obtained.

Insect Attacks in the Vosges.—It was possible to examine personally numerous instances of insect attack and to collect a certain number of specimens as already mentioned in Part IV.

It is a noteworthy fact that in France, as across the frontier in Germany and in fact in all countries where the forests have been systematically managed for a long period of years, the attacks caused by insect pests are always a source of grave consideration and money is always available to counteract them, the moment an attack becomes at all severe. The attacks of Buprestidæ, Cerambycidæ and Scolytidæ are at times so bad that the forest yield is restricted to firewood alone and there is a consequent very heavy loss. At other times large areas have to be felled, many years before their time, with the inevitable resulting dislocation to the working plan proposals, in order to stamp out serious attacks. The severe invasion of *Scolytidæ* from which these forests were suffering at the period of my visit has already been alluded to.

G. I. C. P. O.—No. 3710 R. & A.—250.—10-5 1905.—H. R.

Forest Bulletin No. 6 1906.

MEMORANDUM

ON

MECHANICAL TESTS OF SOME INDIAN TIMBERS.

BY

W. H. EVERETT, B.A., B.E., M.I.Mech.E., M.I.E.E.,
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CALCUTTA:
GOVERNMENT OF INDIA CENTRAL PRINTING OFFICE,
8, HASTINGS STREET.

Forest Bulletins previously issued.

No. 1.	1905	. A Note upon the "Bee-Hole" Borer of teak in Burma.
No. 2.	1905.	. A Note on the Quetta Borer (*Æolesthes sartus*).
No. 3.	1905.	. A Note on the Chilgoza (*Pinus gerardiana*) Bark-Boring Beetles of Zhob, Baluchistan.
No. 4.	1906.	. The natutal growth and artificial propagation of *Ficus elastica* with a description of the method of tapping trees and of preparation of its rubber for the market.
No. 5.	1906.	. A Note on a visit to some European Schools of Forestry.

MEMORANDUM

ON

MECHANICAL TESTS OF SOME INDIAN TIMBERS.

DURING the last three or four years the Forest Department has sent specimens of many Indian timbers to Sibpur Engineering College for mechanical testing. I have now tested about 100 pieces, out of nearly 500 received, and it appears advisable to give some account of the results obtained.

After some consideration I decided to limit the strength tests of each specimen to three, *viz.*, shearing along the grain, endwise crushing, and bending. Tests of stiffness have been made during the bending tests. Timber never fails in tension; and tests of transverse crushing do not give definite results, as the yielding is gradual. For the shearing tests a clamping block was made, after preliminary trials, designed to prevent the test piece from bending at the middle and ends, thus leaving it no alternative but to shear. In preliminary experiments this apparatus was found to give consistent results on test pieces of teak ranging in thickness from ½″ to 2″; but I adopted 1″ as the standard thickness for all the tests given below.

The test pieces for crushing were about 2″ square by 4″ long, except in a few cases where the specimen sent was less than 2″ thick. In every case the test piece was square in section and of length double the side of the square.

The bending tests were made on the full section of specimen sent, mostly about 3½″ by 2″ but more in many cases; and the span adopted was 4′ between supports, the load being applied in the middle. The supports as well as the pressure foot are designed to avoid damage to the test piece by local crushing.

It is a familiar fact that the strength of timber depends considerably on its humidity: partly seasoned wood with $20^{\circ}/_{0}$ of moisture has only about ¾ of the strength of well-seasoned wood with $10^{\circ}/_{0}$ of moisture. Nearly all the present specimens have been seasoned indoors in the climate of Calcutta for two years or more, and are therefore on a fairly equal footing as regards seasoning. Two or three pieces which were tested for humidity were found to have about $10^{\circ}/_{0}$ of moisture, but it was not feasible to test all the specimens for this property.

In considering the results it is convenient to use teak as a standard of reference in comparison; and it will be seen that the strongest timbers have rather more than double the strength and stiffness of teak, while none on the list have less than half that of teak. To aid comparison with non-Indian timbers the highest results are here given from tests made on 87 specimens of wood grown in various British colonies, the tests being conducted by Prof. Unwin:—

Shearing	1·246	(Lignum vitæ, from Jamaica).
Crushing	5·96	(Sneeze wood, from Natal).
Bending	9·52	(Red milkwood, from Natal).
Stiffness	1,465	(Mora wood, from British Guiana).

Corresponding results from tests of 32 American timbers, carried out under the direction of the Government of the United States, may also be of interest in this connection. These again are the highest figures, but each is the average of many tests:—

Shearing	0·58	(Cedar elm).
Crushing	4·9	(Pignut hickory).
Bending	8·4	(Do.).
Stiffness	1,220	(Do.).

These results are all given in tons per square inch.

Comparing with the present results, it will be noticed that three of the Indian timbers break the record for shearing strength, two for crushing strength, and two for bending strength. One Indian timber is about equal in stiffness to the best American wood, and is surpassed by two in Prof. Unwin's list of 87.

With regard to the considerable differences in strength or stiffness for two or more specimens of the same kind of timber, these are not due to experimental errors but to actual differences in the pieces tested. The accuracy of the results can be safely relied upon within 1°/$_{0}$ in the case of the strength tests and within about 5°/$_{0}$ in the figures for stiffness. This possible error in the stiffness is chiefly owing to want of exact proportionality between load and deflection for timber, which is never quite homogeneous and thus bends irregularly.

The strength is given in tons per square inch, and the stiffness is Young's modulus of elasticity in the same units. In this respect I have followed Unwin. For comparison with the co-efficient of bending strength "P" given in Gamble's "Manual of Indian Timbers" for some woods, the present results for bending strength should be multiplied by 124·4; and the present figures for stiffness should be multiplied by 5·19 to compare with the corresponding data "E" in the same work.

For the identification of the timbers I am indebted to the Forest Officers who selected and despatched them. A specimen of each timber has been kept for reference.

			Shearing strength along the grain (tons per sq. in.).	Crushing strength along the grain (tons per sq. in.).	Bending strength (tons per sq. in.).	Stiffness, from bending tests, E. (tons per sq. in.).
1	Tectona grandis (*Teak*)	Pegu	0·600	3·19	4·10	570
2	Ditto	Do.	0·580	3·20	4·76	520
3	Ditto	Do.	0·571	2·90	5·40	575
4	Ditto	Do.	0·620	2·81	3·86	405
5	Shorea assamica	Lakhimpur	0·593	2·85	5·27	700
6	Dillenia indica	Kamrup	0·625	3·48	6·2	680
7	Ditto	Do.	0·663	3·09	4·4	635
8	Baccaurea sapida	Do.	0·553	3·15	5·13	630
9	Ditto	Do.	0·377	...	5·05	615
10	Ditto	Do.	0·567	2·71	4·13	515
11	Bischofia javanica	Do.	...	2·81	3·98	...
12	Ditto	Do.	...	...	3·67	380
13	Canarium bengalense	Do.	0·680	2·72	2·15	273

Forest Bulletin No. 6 1906.

MEMORANDUM

ON

MECHANICAL TESTS OF SOME INDIAN TIMBERS.

BY

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NOTE

ON

THE CHILGOZA FORESTS OF ZHOB AND THE TAKHT-I-SULIMAN.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.,

Imperial Forest Zoologist to the Government of India.

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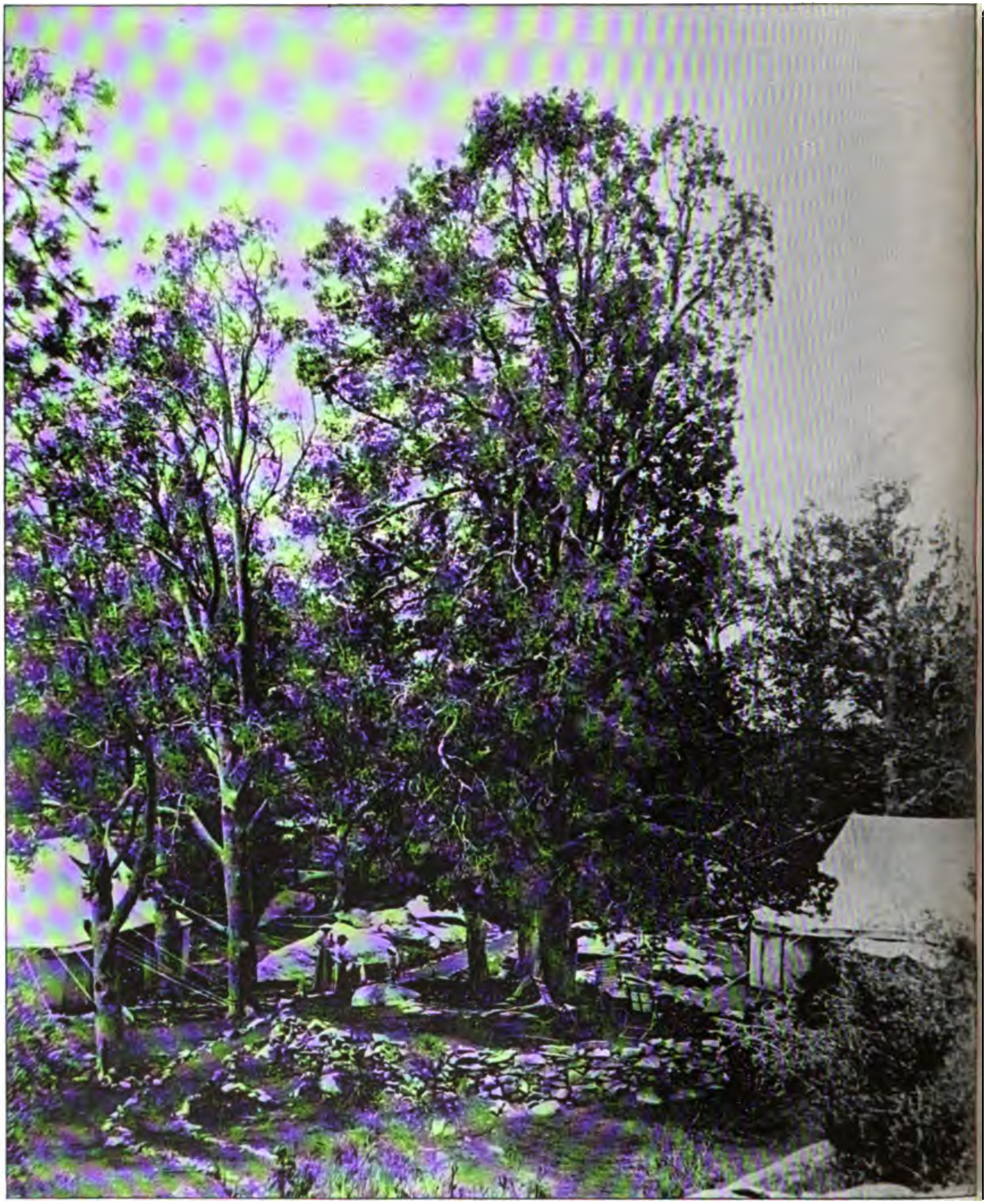

Photo.-Mechl. Dept., Thomason College, Roorkee. Photo. by Capt. R. M. Barron, I. M. S.

A TYPICAL EXAMPLE OF A WELL-GROWN CHILGOZA (Pinus Gerardiana)
Shinghar Forest, Zhob, Baluchistan.

[Frontispiece

NOTE

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NOTE

ON

THE CHILGOZA FORESTS OF ZHOB AND THE TAKHT-I-SULIMAN.

I.—Introductory.

HAVING had occasion during the summer and late autumn of 1905 to pay two visits to the Zhob Agency in Baluchistan in connection with an enquiry into the attacks of bark-boring beetles (Scolytidæ) which are devastating the Chilgoza Forests, I found myself in a position to acquire a considerable amount of information about these fine forests. My summer tour was confined to an inspection of the wooded Shinghar Range of hills. The second visit of investigation, which was principally undertaken to definitely trace out the spread, and ascertain the abundance, of the beetle pests throughout the enforested areas, commenced in the Sherghali Chilgoza Forest. This forest, with but a short treeless interval, stretches in an almost unbroken mass from Sherghali to the Takht. It became necessary, therefore, to carry my researches into this latter area. It should be noted that the forests on the Takht-i-Suliman Mountain Range including the elevated tableland known as Maidan are now included in the North-West Frontier Province.

The question of the reservation or proper management of the Chilgoza Forests of Zhob has been under consideration for the last decade and more. In his Resolution on the Report of Forest Administration in Baluchistan for 1894-1895, Mr. (now Sir Denzil) Ibbetson notes that the report and orders upon it seem to show that the value of the natural forest of Baluchistan has hitherto been somewhat underrated, that protection from fire and grazing suffice to secure the natural reproduction, not only of juniper, but also of ash and other deciduous trees, and that the undergrowth in the closed forests continues to gradually extend. This he considers undoubtedly the most important feature in the report, as it establishes the stability and permanency of forest operations in Baluchistan and materially assists in settling the features of the future forest policy, which, owing to the scarcity of water available for irrigation, cannot, it is understood, be based to the extent once intended on the creation of artificial fuel plantations. With reference to the Zhob Forests the Resolution notes that the Political Agent, Zhob, states that in the Babar, Haripal, and Sherani countries the wooded areas are very extensive and the Government of India desire that the propriety of forming State forests in the Zhob Valley should be taken into consideration and a report on the subject forwarded at an early date. This report was submitted by the Honourable the Agent to the Governor General, its conclusions being generally against the reservation of the Chilgoza Forests. As will be shown in the present note, the important considerations of (*i*) effects on the climate, (*ii*) absence of regeneration owing to grazing, (*iii*) the value of the forests owing to the food-stuff they supply appear to have been left out of account, while the serious destruction now being caused by the beetle pest had not then received recognition.

During the last few years the question was again brought up for reconsideration, and steps are, I am given to understand, in train for carrying out some form of reservation of the Shinghar area.

It is proposed, then, in this note to briefly describe the three Chilgoza Forests of Shinghar, Sherghali, and the Takht-i-Suliman and Maidan, which are roughly delineated on the accompanying map. A short note is also given on the Spiraghar Chilgoza area situated on the hills in the north-west of the Agency, though I unfortunately could not spare the time to visit this forest. The undoubted value of these forests for reasons of climate and water-supply in a country of such peculiar aridness as Baluchistan and the mountains situated to the north-east of the Agency will be discussed.

It will also be shown that apart from their peculiar climatic importance they have a monetary one, not dependent upon the value of the timber which would be generally unsaleable owing to its inaccessibility but due to the edible nature of the seed. I was also given to

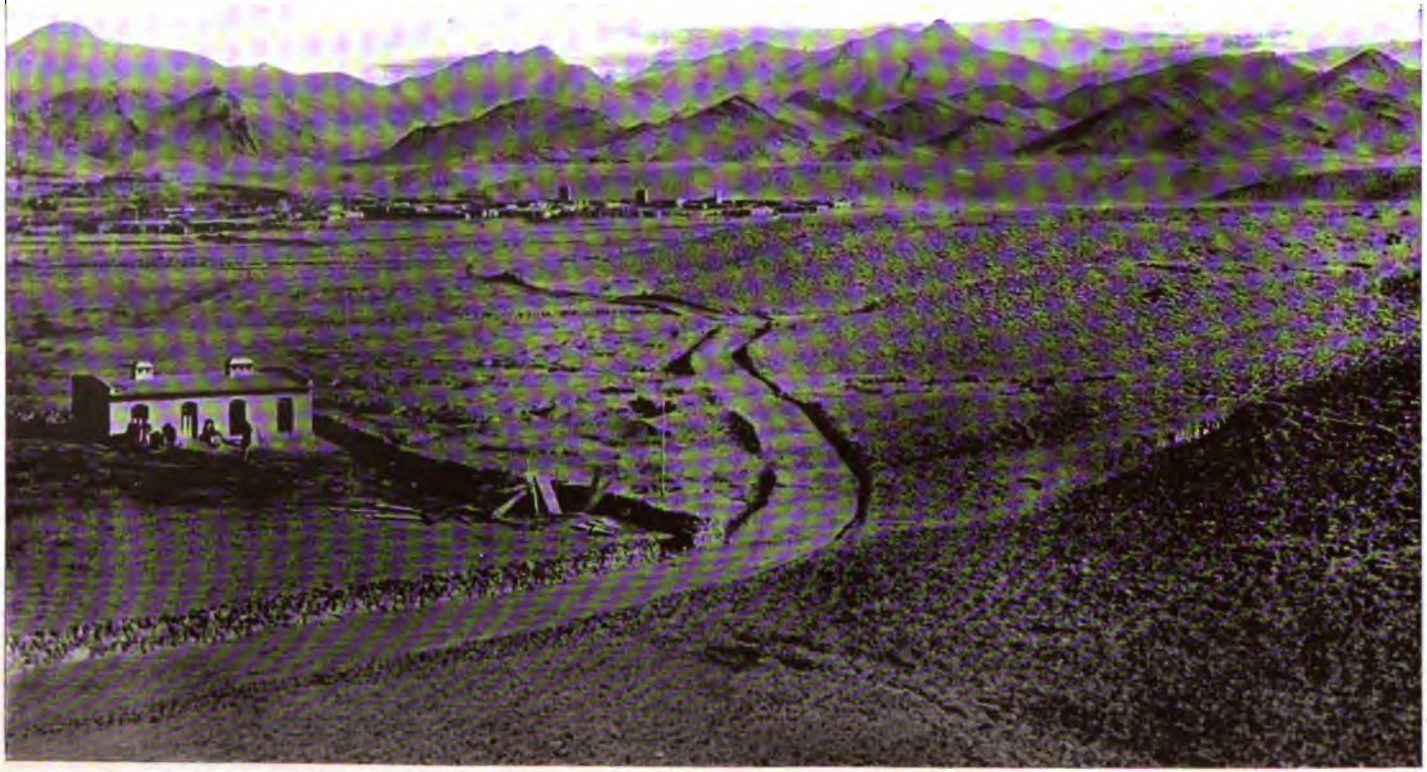

Photo.- Mechl. Dept., Thomason College, Roorkee

Photo by Major E. H. de V. Atkinson, R. E.

ON THE ROAD FROM FORT SANDEMAN
TO MIR ALI KHEL.

understand that their management on up-to-date lines will be a help in the civilization of this part of the Agency. The people would certainly appear to be fully aware of the pecuniary value of the forests and of the necessity which exists for their protection.

Mention will be made of the blue pine present in small quantities both at Sherghali and on the Takht.

In a note already published * as a result of investigations made into the operations of the bark-boring beetle pests, this aspect of the question has been dealt with so far as the Shinghar Forest is concerned. I am able to give here further details upon the spread of these insects, with a photograph showing the appearance of the trees when attacked.

To reach Sherghali from Fort Sandeman it was necessary to pass through a small olive forest at Manikhwa, and a few remarks upon it have been included in the monograph.

I would wish to express here my very great obligations to Lieutenant Colonel G. Chevenix-Trench, Political Agent, Zhob, to whose enthusiasm in the cause of forest reservation and excellent arrangements and kindness my tours became practicable and the drawing up of the former and present monographs has proved possible.

II.—Topography and Geological Formation.

Topography.

The Zhob Agency is situated in the north-east of Baluchistan. Roughly speaking the Agency consists of the Zhob Valley, an immense plain extending from Chari Mehtarzai, the watershed between the Zhob and Peshin (Quetta-Peshin Agency) Valleys, in a crescent form first eastward as far as Mir Alikhel, and then north-east till it reaches the Gomal Valley. Its length exceeds 130 miles, its general breadth, including the stony daman of the hills which border it, varies from about 7 to 15 miles. Numerous small valleys and glens open out into the mountains on both sides. Plate 2 depicts the arid character of the greater part of Zhob. On the west the district is flanked by the Khorasan Mountains, an area of grassy hills occupied during the season by graziers; north are the Spiraghar Mountains whilst in the east and north-east are situated the Shinghar and Sherghali Hills, the latter terminating in the Shahdur Peak which forms the north-east boundary of the district. This latter is practically prolonged into the Takht-i-Suliman situated in the south-west corner of the Derajat District.

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* A Note on the Chilgoza bark borers of Zhob by E. P. Stebbing. Forest Bulletin No. 3 (1905).

The Shinghar Range of hills (elevation 7,800 to 9,300 feet) is situated between the Kibzai and Musa-khel country east of Zhob, and in the Sherani country. They consist of close parallel ridges hemming in narrow valleys and have a strike from north-north-east to south-south-west. These hills are the main watershed between Bori and the Musa-khel country. The Tarick Loara and Sahra, which rise to the east, run in a general north-east direction towards the Indus.

The Sherghali Range of hills is practically a southern prolongation of the Takht-i-Suliman. From the lower forest-clad western slopes of the range a stream rises and flows through the Sherghali cultivated plateau, the cultivation of which is entirely dependent upon this water.

The Takht-i-Suliman is the name given to the great mass situated between the Gat and Dhana Khidarzai defiles. The mass of the Takht itself may be described as a high tableland (known as Maidan) 8,900 feet above sea-level, bounded on the east and west margins by high rims formed by parallel ridges of rugged and steep outline. The western ridge culminates to the north in the highest peak Kaisaghar (11,300 feet), as shown in plate 6, whilst the eastern terminates on the south in the celebrated Takht-i-Suliman (11,070 feet).*

The intervening space between the ridges containing these two peaks is a valley or, more properly speaking, a plateau sloping inward from an average height of 9,750 feet to one of 8,500 feet, two-thirds of its drainage flowing north and one-third south, from a diagonal watershed connecting the two ridges. In this watershed is the plateau called Maidan, which is about 4 miles square with an elevation of 8,950 feet.

---

* The Takht-i-Suliman has been held in great reverence for centuries, and is resorted to as a place of pilgrimage by both Hindus and Mahomedans. The eastern face of the mountain drops in a sheer precipice of several thousand feet to the Derajat foot hills and plains below. In the face of this precipice twenty feet below the summit is a tiny ledge of 4 feet square which is the site of the far famed *ziarat* or shrine. Pilgrims descend into this to worship, the descent being one of considerable difficulty and danger. The commonly accepted legend is that Solomon's throne alighted here on his return from Hindustan whither he had gone to marry a wife.

The northern drainage is carried off by the Gang nala into the Draband Zan. The southern part of the tract drains into a deep nala (Torgai) known lower down as the Dhana Khidarzai or Obo-khel Dhana. The whole of this intervening valley is said to be, according to the Gazetteer, " cut up by deep nalas coming down from the inner slopes of the Kaisaghar and Takht ridges and joining the two ravines above mentioned."

As a matter of fact the northern or upper portions are maidan-like in character, the ravines from the ridges to the east and west assuming small dimensions on the plateau. To the south, however, the latter drops away in a series of small gorges (*vide* map).

Geological Formation.

The Zhob Valley is an alluvial plain. The Shinghar and Sherghali hills consist of black sandstone and white limestone. The western face of Shinghar is curiously stratified. It is precipitous and presents a singular appearance rising in alternate layers of black sandstone and white limestone tilted at an angle of 45° towards the south. The Takht-i-Suliman and Maidan consist of coral limestone. Boulders are numerous in the Shinghar and Sherghali ranges as also on the valleys and hills approaching the Takht from the west and on Maidan and the parallel ridges of Kaisaghar and the Takht-i-Suliman.

III.—Climatic Conditions.

The climate of Zhob, which for the greater part of the year has a peculiarly dry atmosphere, is said to be intermediate between that of the Punjab and the Peshin Valley. Night frosts are experienced from about the end of November to the end of March. The summer heat is high during the day, but the nights are tolerably cool. The high hot winds which sweep up the long valley into the hills, raising clouds of dust from the arid countryside, are a source of considerable annoyance and they doubtless determine the character of the vegetation to a certain extent. The rainfall is expected in January and February, with showers in July, August, and September. It amounts to a mean fall of about 8 inches annually. Snow sometimes falls in the valleys, but does not lie long; but the high ranges to the north are snow-covered for weeks. Snow, frost, and ice are doubtless responsible for a certain amount of damage in the Chilgoza Forests.

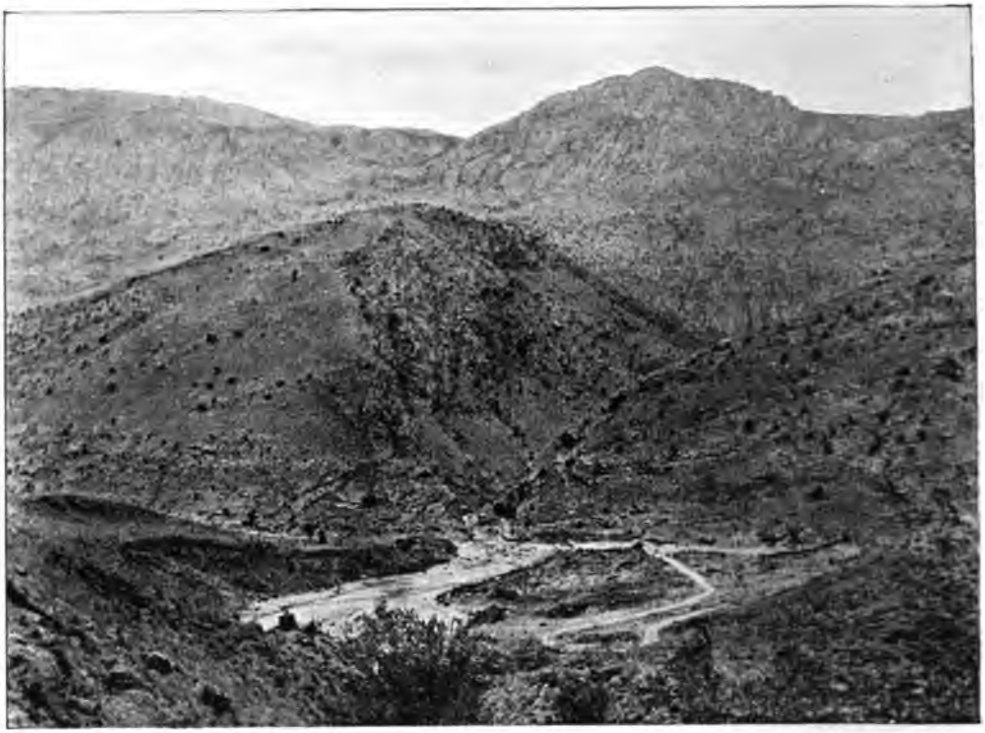
The snow, however, is by no means an unmixed evil, since, when it melts in the spring, it fills up the subterranean reservoirs which probably exist in the limestone formation and thus preserves the forests from disappearing through the otherwise great dryness of the country.

The Chilgoza is evidently a wonderfully hardy tree. On the Takht and Maidan the climate is severe in winter with heavy snowfalls, and yet it was not apparent that either the Chilgoza or the blue pine suffered from snow break. The stormy gales also which sweep over Maidan do not appear to have any disastrous effects on the forest, except that, perhaps, trees on very exposed shoulders are to a certain extent stunted and much branched. The aqueous deposits are chiefly in the form of snow in the winter months. Our party experienced a sleet storm on November 12th, 1905, and Captain Alexander mentions a heavy rain storm in May of the same year.

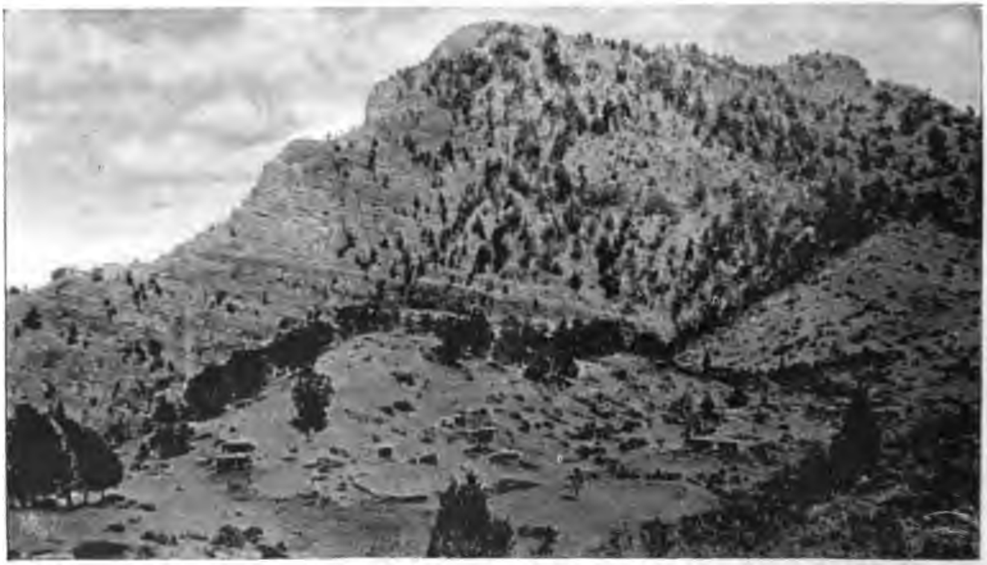
IV.—Character of Vegetation.

Owing to its arid, sandy nature, the southern and central portions of the Zhob Agency are destitute of forests proper (*vide* pl. 2). Great stretches of desert are here and there covered with tamarisk or scattered trees; the small blocks of forest found in parts consist of the genera Pistachia, Fraxinus, Olea, Acacia, Zizyphus, and Tecoma, genera peculiar to desert regions.

The vegetation, however, entirely changes in the northern mountainous portion of the district. Here forests approaching the character of the Himalayan coniferous areas are seen occupying the mountain tops or clinging to the slopes of the hills. The chief tree of these woods is the Chilgoza pine (*Pinus Gerardiana*) (*vide* frontispiece). The tree forms practically the only species in the Shinghar Range and the same is the case at Sherghali with the addition of a little blue pine (*Pinus excelsa*), known locally as nashtar, near the top of the western crest. Again on the slopes of the Takht-i-Suliman and on Maidan the Chilgoza is the principal or prevailing species. There are some blue pines in the main nalla (Torgai) leaving the Maidan on the south and some more on the upper slopes of the Takht, and again, more abundantly, on the Kaisaghar. Amongst the shrubs and plants found on these hill ranges may be mentioned Ephreda, Berberis, Cotoneaster, Spiræa, wild almond, dog rose and, on the lower slopes of the Takht, hawthorn and gorse, etc.



ARID HILLS AND VALLEYS,
With a litle olive and Pistachio Forest on the lower slopes.



A MOUNTAIN SLOPE IN ZHOB,
becoming gradually denuded of Chilgoza Trees under the adverse influences
of grazing and the attacks of the bark-boring beetles.

Photo.-Mechl. Dept., Thomason College, Roorkee.

V.—Forest Growth in Zhob.

The forests in Zhob may be divided into two groups:—

1. The deciduous forests of the plains and low hills.
2. The coniferous forests on the northern and north-eastern mountain ranges.

The Deciduous Forests.

Since this note has for its object a description of the Chilgoza Forests of the district, any lengthy notice of the deciduous forests would be out of place. The species present are represented by the genera Pistachia, Olea, Fraxinus, Acacia, Zizyphus, and Tecoma principally, with tamarisk more or less scattered over the countryside. These trees occur in small blocks of forest, usually pure, the density varying from ·2 to ·5 on an average. Although strictly 'forests' in an arid country like Baluchistan, they do not, perhaps, fulfil the generally accepted or conceived idea of what a forest should be or is like. The upper photograph in plate 3 depicts some scattered olive and pistachio forest in Zhob.

As I shall not return to a consideration of these forests, it may not be out of place to give a short description of the Olive (*Olea cuspidata*) Forest of Manikhwa and neighbourhood, since it forms a typical example of these deciduous areas. This forest, which is almost pure olive, commences at the tenth mile on the Fort Sandeman-Manikhwa road (2 miles out of Kapip) and ends at Manikhwa, 24 miles from Fort Sandeman.

It is mostly situated to the north of the road, occupying the narrow strip of plain in the valley and clothing the hillsides to their crests, several hundred feet above the valley bottom. The density varies in parts, but may be taken generally as ·5. To the south of the road the trees appear in patches only on the hills, which are much more abrupt and precipitous, and have a greater elevation. The growth of the trees in the plains strip to the south of the road is excellent, and there is every indication that this forest is one of considerable value. Natural regeneration, however, is by no means as good or as abundant as is required, and the reason is not far to seek. The forest is situated close to a thoroughfare which is a high road for powindahs on their way to Dera Ismail Khan. A grazing tax of R1-8 per male and annas twelve per female camel is levied from the powindahs, a pass being given for the six months occupied on the forward and backward journeys. Bullocks, sheep and donkeys are also taxed according to a scale. It would be perhaps advisable in the case of this forest, if certain portions of the area were closed for periods long enough to permit the natural regeneration essential to the maintenance of tree growth on the area to come up. At present this forest, and all others on the routes taken by the powindahs, is suffering severely at the hands of people who do not live in the country to the detriment of the local inhabitants. It is almost needless to state that, if left unchecked, there can be but one end to such a state of affairs—the disappearance of the forest so treated.

Being so accessible there is no difficulty in disposing of the products of this area, which consist principally of the wood and the fruit.

It is hoped to be able to introduce the olive from the south of France and arrangements have been made by Colonel Trench to obtain grafts from French stock.

The Political Agent has enclosed about one square mile of the forest round the Manikhwa bungalow in order to stop grazing and wanton destruction. He hopes to show the people what such protection really means towards the amelioration of a forest of this kind.

The Coniferous Forests.

The coniferous trees found in Zhob consist of two species of pine, the Chilgoza (*Pinus Gerardiana*) and the blue pine or nashtar (*Pinus excelsa*), and a Juniper (*Juniperus excelsa*). With this latter tree we are not here concerned, the finest forests of this species in Baluchistan being outside the limits of the Zhob District. The most important of the two pines is the Chilgoza, the blue pine occurring with it sparingly in a few places. In parts of Zhob, and the remark applies to the forests on the Takht-i-Suliman and Maidan, which are of the same character, the Chilgoza is seen at its best, and fine, straight, tall trees 9 to 12 feet in girth and 70 to 85 feet high are to be found between elevations of 7,500 to 8,500 feet or so (*vide* frontispiece). The tree will grow on what appears to be solid limestone rock, and its source of water-supply is often a mystery. Hillsides, apparently a mass of sheet rock, paved with great blocks or covered with stones and boulders of the same material, are found clothed with a forest of comparatively great density. In the absence of this forest covering rain would run off such slopes immediately; even with the covering it disappears very quickly, and the only probable conception is that some at least of this water percolates through fissures, and is retained close to the surface in subterranean depressions.

As has been already mentioned, the forests to be considered in this note are the Spiraghar, Shinghar, and Sherghali in Zhob, and the Takht-i-Suliman, Kaisaghar, and Maidan areas in the North-West Frontier Province.

The Fruit Gardens and Forest Nurseries.

When treating of the forest growth of Zhob a mention of the fruit gardens is necessary, since they all contain what are to all intents and purposes forest nurseries. From these the station of Fort Sandeman is being planted up as also are the compounds of the various dâk bungalows of the district. Young trees are also given out to inhabitants of the country for planting in the villages and along water channels. A great deal can be done in Zhob and throughout Baluchistan in this latter connection. Of course planting work depends entirely upon the presence of water, but that all the sources of water existing in the country are known would appear to be open to considerable doubt. For instance, Colonel Chevenix-Trench discovered at Manikhwa in May 1905, with the aid of an Afghan professional water-finder, a spring in the hills just north of the road within less than half a mile of the village at that place.

The discovery has enabled the Political Agent to plant a number of apricot, walnut, ash, almond, mulberry, and fig trees round the bungalow, as also vines. It is hoped that it will be possible to form a garden on a considerable scale at the place, from which to distribute trees; and eventually, if gardens can be increased, to supply Dera Ismail Khan with fruit and vegetables during the summer months, when they cannot be produced at that place.

VI.—Necessity for the Protection and Amelioration of the Chilgoza Forests.

The question of the reservation of, or the granting of protection in some form or other to, the Chilgoza Forests came to the front a little over a decade ago. Previous to this Mr. Elliott, when Deputy Conservator in Baluchistan, had paid a visit to the Chilgoza Forests of

Spiraghar and Shinghar, and had seen, from a distance only, the trees on Kaisaghar and the lower approaches of Maidan. He wrote a report on his visit.

Of the trees in the Shinghar Forest Mr. Elliott wrote: " Many trees are dead, the cause in some cases being fire, in others probably the severe conditions of life, considerable heat in summer, great cold in winter, high winds at all times, and scanty rainfall." Mr. Elliott considered that no special protection was required. I have already shown elsewhere * that the dead trees at Shinghar are almost, if not entirely, the result of the depredations of some bad bark-boring beetles, and that the above quoted remarks of Mr. Elliott cannot be regarded as in accordance with the true facts of the case. His observations on the Takht Forests do not call for remark, since he did not visit the area. In 1896, the Government of India having called for a report on the subject, the question was carefully considered by the Political Agent of Zhob and the Forest Officer in Baluchistan. In June 1897, the Political Agent of Zhob wrote that he considered the Shinghar Forest to be of considerable value, and that he had restricted cutting to the Sherghali Forest. The decision on the question then arrived at by the Honourable the Agent to the Governor General, that there was no call for the reservation, was apparently based upon —

(*a*) that the tribes did not require it and it would not be advisable to act contrary to their wishes at that time;

(*b*) that there was no possibility, owing to their inaccessibility, of extracting timber from these forests;

(*c*) that grazing in the forests did not appear to be practically harmful.

The matter was subsequently re-opened. In 1900, Mr. Down, who had relieved Mr. Elliott as Deputy Conservator in Baluchistan, paid a visit to the lower slopes of Shinghar, and in his report re-quoted Mr. Elliott's remarks about the cause of the dead trees in the forest. He did not, however, make a thorough inspection of this forest, and did not visit any of the others. In 1904, Bhai Sadhu Singh, Extra-Assistant Conservator in charge of the Baluchistan Forests, who had relieved Mr. Down on the latter's retirement from the service, visited the Shinghar and Sherghali Forests in company with the Political Agent,

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* *Op. cit.*, pp. 15, 16.

Colonel Chevenix-Trench. Bhai Sadhu Singh's extremely able note upon this visit is most instructive.

A weightier reason even than those already recorded in favour of some form of protection being given to the Shinghar Forest was, however, brought to light by Colonel Chevenix-Trench in 1903. He reported to the Inspector General of Forests that the trees at Shinghar appeared to be dying off under the attacks of some insect. Major McDonald, when Political Agent of Zhob in 1898, seems to have first recorded this fact, but no practical steps were taken until Colonel Trench took action. I have already dealt with the serious nature of this infestation.* With these various reports before them the Baluchistan Government have, I understand, decided to move in the matter, and the reservation of the Shinghar Forest at least is under consideration, and is, as will be shown, in an advanced stage. This, by itself however, will not be sufficient.

Curiously enough, the value of these forests owing to their great influence on the climate and continuance of the water-supply does not appear to have been taken into consideration, nor, until recently, has the value of the edible seed of the Chilgoza pine apparently been accorded the importance it merits.

The weight of the evidence now collected in favour of the reservation, or at any rate protection, of both the Shinghar and Sherghali Forests (as also, it would appear, the Spiraghar, which I have not seen) would seem to be singularly strong. The reasons which demand such protection may be summarised as follows :—

(*a*) The continuance of the flow of the springs and small rivers emanating from these mountain ranges undoubtedly depends solely on the hills remaining covered with forest. Already it has been possible to trace in several instances the fact that in certain springs the water-supply is growing less year by year, a natural consequence of the destruction of the forests on their catchment areas.

(*b*) The cone of the Chilgoza pine contains seeds of an edible nature. These seeds are a well-known article of food throughout these hills and the Punjab, and are collected by the various sections of the tribes living adjacent to the forests and claiming the right of such collection over particular areas. The sale of the seed is a source of considerable profit to the tribesmen. The disappearance of the forests through neglect and wanton damage will cause this source of income to shrink year by year.

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* *Op. cit.*

(*c*) The tribesmen themselves are desirous that the Shinghar Forest should be protected, and the same may, the Political Agent considers, be said of Sherghali.

The direct reasons for protection are—

(*i*) Owing to unregulated grazing and to the method of collecting the Chilgoza seed (which latter, as will be shown, is in itself a reason in favour of protection), natural regeneration is in many parts either very poor or entirely absent. This, of course, means that it is only a question of years for the forests to disappear through the gradual dying off from old age of the present crop occupying the soil.

(*ii*) A still weightier reason, however, exists, rendering it imperative that immediate steps should be taken to look after these areas. The present crop on the ground, if left to itself, will not be allowed to disappear through natural causes. Young poles and old trees, green and vigorous, are being killed off by species of bark-boring beetles * to an alarming extent. Each tree killed means so many cones less annually, and consequently a pecuniary loss to the tribesmen.

The lower photographs on plates 3 and 4 demonstrate the damage being done to the forests by grazing and the attacks of the bark-boring beetles.

Such are the chief reasons put forward by the advocates of the protection of these fine forests. The fact that their inaccessibility prevents the removal of the timber from them is in itself on the side of protection, since the seed of the tree with its annual yield is a much more valuable product than the timber. This statement as to their inaccessibility for cutting purposes, however, is unfortunately not in accordance with the facts of the case. Shinghar is inaccessible, but trees are cut in Sherghali—dead trees only, it is said—but it is easy to ring a fine tree in an accessible situation so as to ensure its being dead the following year. Cutting, as will be shown hereafter, is also taking place in the Takht and Maidan Forests, and the lines upon which it is being carried on are to be most seriously deplored.

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* Polygraphus Trenchi, Phlœosinus sp.
Pityogenes coniferæ.

VII.—The Chilgoza Forests of Zhob.

It is proposed to deal here at some length with the Shinghar and Sherghali Forests.

SHINGHAR FOREST.

Situation and Configuration.

The Shinghar Forest is situated on the hills of that name at a distance of some 30 miles from the head-quarter station of Fort Sandeman. This range of hills, which has a north-north-east to south-south-west direction, forms the southernmost termination of the great Takht Range and ends in sand-hills to its south (*vide* map). The forest is situated roughly between 7,800 feet and 9,300 feet above sea-level. A few scattered trees are to be found below the lower elevation, the upper one being the height of the Survey Bench mark on old Shinghar Hill. The range consists of a saddle connecting a number of spurs projecting from its eastern face, all more or less covered with trees on the upper portions; the western face is mostly of a precipitous nature the whole length of the range, and in places drops sheer down to the Sherani country below. It is clothed with trees wherever the configuration permits of their growth. The saddle rises to the north ending in the old Shinghar Hill. Skirting round the base of this hill, and still proceeding in a northerly direction, the ground continues to rise through forest to a small open maidan. From this it drops away for approximately two or more miles, consisting of what is really a succession of small spurs with a general east and west trend. The spur jutting out from old Shinghar, which has the small maidan on its western edge, is by far the largest, being considerably over two miles in length. Its southern face is precipitous, whilst its northern slopes gently. The southern portion of the range is known as new Shinghar, the district bungalow and new dâk bungalow being situated at this end.

Area.

The area of the Shinghar Forest is approximately 9·2 square miles. As no survey has been made, this must be taken as an approximate estimate only.

Boundaries.

The boundaries were demarcated and laid down in the summer of 1905 by the Political Agent and the Extra-Assistant Conservator of Forests in Baluchistan. Demarcation pillars, consisting of cairns of stones, have been erected. Their position is shown roughly on the accompanying map. I am given to understand that the maliks of the section of Sheranis and Haripals claiming rights in this forest have agreed to these boundaries, subject to certain stipulations which will be considered in a subsequent paragraph, and have signed an agreement to this effect.

Forest Growth.

The forest consists of an uneven-aged growth of pure Chilgoza. The density of the crop varies considerably, by far the finest portion being situated on the area to the north of the old Shinghar Hill. The average width of the forest may be taken as a mile, the trees in places thinning out to much less, whilst in others, and notably in the better portions, the width is much more. It should be noted that the Chilgoza tree as found here has a spreading habit (*cf.* pl. 1). This, however, cannot be looked upon as the defect it would be in forests of other species, since, whilst serving to cover the ground to a greater extent, the tree at the same time yields a larger number of cones. On the other hand greater density in the crop would fulfil the same purpose. Mr. Elliott, in his report before alluded to, attributes this irregular habit of growth of the tree to poor soil and strong winds. A careful examination of young trees led me to the belief that it was more probably due to the unrestricted grazing to which the forest has always been subjected. The southern portion of the area (new Shinghar) is very open, the trees being in places much scattered, stunted, and having the gnarled and spreading appearance of old oaks in Europe (*cf.* pls. 4 and 5). Along the saddle connecting the southern and northern areas the trees are scanty and of small size. As already remarked, in the northern portion the growth is densest, the trees being of greater height and girth, and the forest is of considerable value. Perhaps an average all-round girth of 5 feet might be given for the area, but trees of 8-9 feet girth and even over are to be found fairly plentifully. The height growth varies greatly. The largest tree I measured had a girth

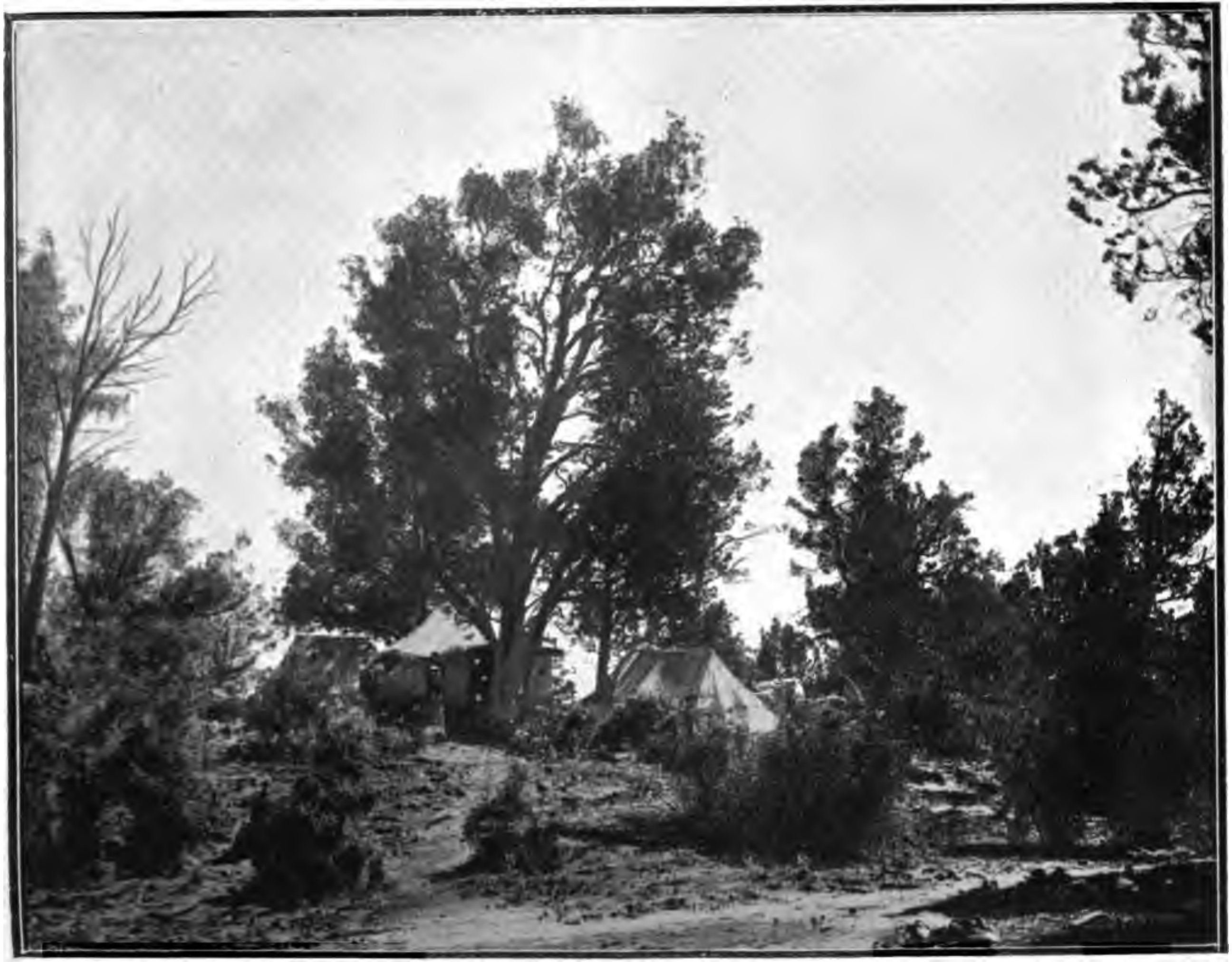


Photo.- Mechl. Dept., Thomason College, Roorkee

Photo by Major E. H. de V. Atkinson, R. E.

YOUNG CHILGOZA GROWTH AT SHINGHAR.

of 15 feet and height of 70 feet. At old Shinghar there are one or two trees of a still greater girth. Bhai Sadhu Singh, the Extra-Assistant Conservator, made the following approximate enumeration of the trees on new Shinghar, the poorer and most openly stocked part of the forest:—

1.	Saplings	1,527
2.	Trees under 12 inches girth at breast height	587
3.	Trees from 12-18 „ do. do.	1,460
4.	Do. 18-24 „ do. do.	1,447
5.	Do. 24-30 „ do. do.	867
6.	Trees over 30 „ do. do.	357
7.	Dead trees	983
	TOTAL	7,220

No enumeration has yet been made of the fine forest at old Shinghar, except that 268 trees infested with the beetle were counted.

As will be seen from this table, the percentage of dead trees is very large, by far the larger number having died under the attacks of the beetle pests to which we shall return later on. No one could visit Shinghar without being struck with the numbers of the dead trees, their white stems and larger branches, from which in many cases the bark has fallen, and their needleless crowns rendering them very conspicuous.

The forest has all the appearance of having occupied the locality for a considerable period of time. I unfortunately, however, had no opportunity of ascertaining the probable age of the older trees.

Natural regeneration is in parts fair, and more especially so round the district bungalow and adjacent areas which are occupied by the summer encampment of the officers of the station of Fort Sandeman. Here grazing has been forbidden for some seasons past, and the result is that a good crop of young saplings have made their appearance. This and the noteworthy fact that most of the young saplings are found in the centre of thorny thickets, as depicted in plate 4, would appear to indicate that to the unrestricted grazing of the cattle over the entire forest, which has been the custom, must be attributed the absence of natural regeneration on the greater part of the area. The heavy collection of the cones by the tribesmen is also another reason. The trees fruit well, the tables given in Appendix I being from countings made by Bhai Sadhu Singh. Sixty trees were counted and the average number of cones borne by a 5 feet 1 inch tree was found to be 69, the average number of seeds in a cone being 33. Where they exist the young trees are healthy, well-grown saplings apparently free from disease, and also, at this age, from the attacks of the beetle pest.

The undergrowth which in parts is sufficient to cover the ground, consists chiefly of Berberis, Ephreda, Rosa, Cotoneaster, Spiræa, wild almond, and mountain ash. A cuscuta climber is found in places and appears to injuriously affect young trees by checking their growth.

At the foot of the range olive, ash, and pistachia trees are found.

Treatment.

The present management of the forest and forest operations will be considered here.

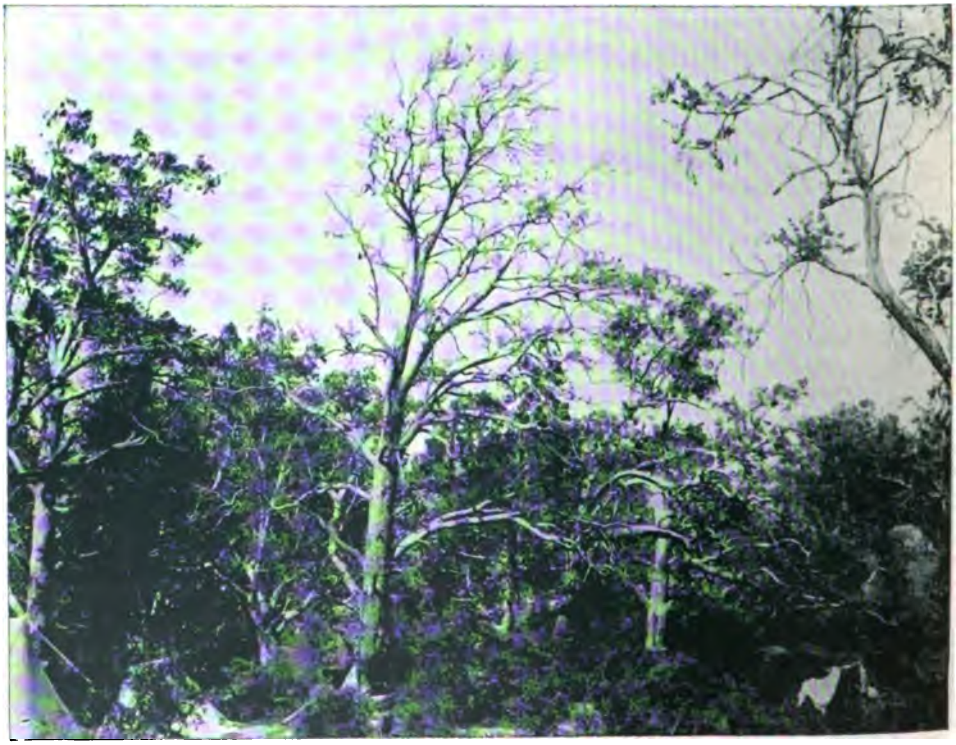
Management of Forest.—The management of this forest is in the hands of the Political Agent who has the power of consulting with the Forest Officer in Baluchistan.

Staff.—The staff till recently has consisted of one forester and five guards for the forests of the whole of Zhob. It is admitted that nothing had been done previous to 1905 with the object of improving the growth on the area in question, nor was much feasible when the paucity of the establishment is taken into account. I understand that proposals are now under consideration for placing a trained Ranger in charge of Shinghar and Sherghali, and it is suggested that should such an officer be appointed, he should have under him at Shinghar two guards and four beldars. These latter men would carry out works of improvement, such as felling insect-attacked trees, opening out forest paths, sowing and planting work, etc. One of the conditions of the Sheranis on agreeing to the demarcation was that these posts should be filled by men from their sections, a condition readily acceded to by the Political Agent.

Protection.—Grazing.—Until recently no attempts at protection have been considered feasible. One of the chief efforts necessary in this direction, it is now fully recognised, is the prohibition of grazing, especially that of goats. It is considered that the steps taken to demarcate the forest with the consent of the Sheranis and Haripals will result in the grazing being put a stop to within the limits of the area demarcated, and this in itself is a long step in the right direction.

Insects.—In addition to the grazing question we have seen that another has arisen out of the serious depredations of the bark-boring

A HEAP OF EMPTY CHILGOZA CONES,
This illustrates the way in which the green cones are heaped together in the forest and burnt.
Under the influence of the heat the cover open and the seeds are then extracted.



CHILGOZA TREE KILLED BY THE BARK BEETLES
Polygraphus Trenchi and Phlocosinus Sp.
This picture illustrates the manner the insects spread from tree to tree Shinghar Forest.

pests. I have already discussed these in my paper on the subject* and suggested the steps to be taken to combat, and, if possible, stamp out the pest in this forest. My visit to Shinghar terminated in the latter part of June, and from that date onwards until he returned to Fort Sandeman, the Political Agent personally interested himself in the felling and burning of badly infested trees. I understand from the Extra-Assistant Conservator of Forests that 82 badly attacked trees were felled and burnt in the new Shinghar portion of the forest, and that as many as 268 infected trees were counted in old Shinghar. The latter could not unfortunately be taken in hand during 1905 owing to the want of funds and staff. The reason for felling the trees was explained to some of the maliks by the Political Agent and myself, and they were personally shown recent badly attacked living trees which were full of the beetles. They were fully aware that such trees would die, and the cause of death was explained to them. In spite of the disparity in numbers of infested trees as shown by the countings, new Shinghar appears to have suffered more from the beetles than old Shinghar. The large number of dead trees in new Shinghar, 982, probably accounts for the smaller number of green ones attacked, since the trees are now much more scattered.

The photograph on plate 5 illustrates the manner in which the trees are dying off in this forest under the attacks of these pests.

Forest Operations.—Fellings.—No fellings have been made in this forest. A tree may have been cut here and there by a tribesman, but there has been no removal of wood for sale purposes. The felling work undertaken in the summer of 1905 had solely for its object the removal of trees infested by the beetle pest.

Collection of Chilgoza seed.—As has been already explained, it is the edible nature of the seed of the Chilgoza pine which gives the pecuniary value to this forest, and this seed has apparently been collected for a long time past by the tribesmen living adjacent to the forest and claiming it as falling within their jurisdiction. It is the opinion of the Political Agent that it will be advisable to admit this claim on the part of the tribes. The collection of the cones is undertaken by the tribesmen themselves and the present methods account in part for the 'ragged' appearance of the crown of so many trees on the area. To obtain the seed men climb the trees and by means of long poles to the end of which a hook is affixed they wrench from the boughs the seed-bearing cones. The wrench invariably breaks a portion of the branch, with the result that a tree plucked of its cones is bleeding at numerous places and is in a condition most subject to the attacks of the beetle pests. Not only is the tree injured, but owing to the greed of the tribesmen scarcely a cone is left upon the trees to yield seed for natural regeneration purposes. After collection the cones are gathered together in heaps and burnt whilst still green. The heat forces open the cone scales and the seed is then picked out. This is the method adopted in all the Chilgoza areas with which this note is concerned, and during a march through these forests heaps of empty cones, collected in the centre of some small glade, as shown in the uppermost photograph in plate 5, will be often met with. It need scarcely be pointed out that it would be difficult to find a worse method of collection than the one at present in force amongst the tribesmen.

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* *Op. cit.*

The price obtained for the seed is said to be Rs. 10 per maund. Five hundred maunds or Rs. 5,000 is considered to be the total amount collected from the Shinghar, Sherghali, and the southern portion of the Takht Forests whose seed is brought out *viâ* North Zhob. These figures were obtained for me through the Political Agent's office.

Collection of other minor produce.—The Chilgoza trees are occasionally tapped for resin. This operation will be described under the notes on the Takht and Maidan Forest. No tapping was noticed in Shinghar, but I was unaware at the time that such an operation was ever undertaken.

Future Treatment.

The future management of this forest does not appear to present any great difficulty, provided (1) the tribesmen, should the area be reserved, loyally carry out their part of the bargain. As it is so obviously in their interest to do so, this conclusion may perhaps be deemed a probable one. (2) That an adequate staff with a trained ranger is available to carry out the work.

Boundary.—A boundary has been laid down and pillars erected (*vide* map). As soon as this demarcated line has received the assent of Government (it has already been agreed to by the tribesmen), particular care should be taken to see that the boundary pillars are maintained in repair and that none are removed.

Management.—The forest should be treated as an uneven-aged wood. I understand that it is proposed to sow or plant up the blanks caused by excessive grazing and the attacks of the beetle pests.

Forest Operations.—Fellings.—No green tree should be felled, and if the removal of dead ones is allowed, it should only be after they have been marked for felling by a forest officer. This rule would not apply to operations having for their object the stamping out of the beetle pest, but all such trees should be first marked and the search for and selection of them not left to the tribesmen.

Grazing.—No grazing whatsoever should be permitted within the area demarcated by the boundary pillars.

Collection and disposal of seed.—This is a question which still remains for settlement. It is one for the consideration of the Political Agent whose knowledge of the tribesmen will enable him to say what steps are possible towards—

(1) ensuring a better collection of the cones with the object of saving the trees from the mutilation to which they are now subjected;

(2) ensuring that a certain number of cones remain on the trees in order to obtain regeneration in the forest. This latter is a most important point.

For the present I should advise, pending a settlement of the seed question, the formation of one or two nurseries, say one at new and another at old Shinghar, and the purchase of some seed from the tribesmen to stock them.

If there is a possibility of collecting the seed through Government agency under the supervision of forest officers, it should be done. Colonel Trench informs me that he thinks the tribesmen at Shinghar would regard Rs. 1,000 annually as the most they could hope to obtain for the seed from that area. With their own relatives as guards and beldars in the forest, drawing a monthly wage from Government, and a certain fixed annual sum per year for seed, it appears possible that they would take a considerable interest in the protection of this forest; and that such protection is urgently and early needed it has been the purpose of the foregoing remarks to show. With the right to collect the seed as they liked the Political Agent and Forest Officer would be able to ensure obtaining natural regeneration, and with the forest closed to grazing they could be confident that the young plants would grow up. The remainder of the seed would command a ready sale, and with a more careful collection and extraction from the cone (which is done most carelessly by the tribesmen) it is probable that a sum equal to that at present obtained would be realizable, even with a lighter collection.

SHERGHALI FOREST.

Situation and Configuration.

The Sherghali Forest is situated 22 miles to the west of Shinghar on the western slopes of the Suliman Range. The area occupied by the trees forms practically the southernmost end of the Takht-i-Suliman, the ridge running north and south. The western slopes of this ridge are cut up by projecting spurs, the forest occupying both ridge and valley in a more or less continuous block which thins out on the northern slopes of the kotal immediately to the south of Sikhan ziarat. Southwards the ridge drops to the Sherghali ravine. Climbing up from this ravine through forest one comes upon the Sherghali plateau, an undulating area situated at the foot of the forest-covered western slopes of the Sherghali Hills. This plateau is of considerable extent, being bounded to the west by a rocky ridge. To the north it rises and then dips; the forest closes in again here and extends north through Wachobai over a succession of kotals running east and west. The actual Sherghali ridge culminates in the great Shahdur peak which on its northern side drops sheer to the Obo-khel Dhana. A reference to the map will show the position of the forest.

Area.

The area of Sherghali is roughly estimated at 3·5 square miles.

Boundaries.

I understand that the Extra-Assistant Conservator has been over the ground with the Political Agent and that they have approximately decided upon the boundaries of the area. Briefly and roughly they would be the Sherghali ravine on the south; the crest of the ridge, which is the boundary of the district and province, on the east; Sikhan kotal (where there is a small ziarat), the kotal above Zgumiser where the last visible water going north towards the Takht-i-Suliman is obtainable and along which the frontier district and provincial boundary runs, on the north; and a line following the edge of the forest, which is very irregular, on the west. This line would run to the east of Sherghali plateau, which is cultivated by the Sheranis who have a summer village in the north-east corner. This area has been roughly delimitated on the map.

Forest Growth.

The forest consists, as at Shinghar which it resembles to a certain extent, of an uneven-aged wood of pure Chilgoza pine mixed near the crest of the eastern ridge immediately above the Sherghali plateau, and only here, with a little blue pine. There are, however, a few blue pine on the precipitous northern face of Shahdur—fine, straight, pyramidal trees growing straight up in the precipice face. What may be termed the Sherghali forest proper, however, is pure chilgoza. In parts the crop is of very fair density, and this is invariably the case wherever the extreme ruggedness of the ground is modified. Immediately to the north of the plateau and round Wachobai there is some very good growth. The great feature of this forest, as compared with its neighbour Shinghar, is the abundance of the advance growth and the excellent promise of the young trees. As we shall see, this must be attributed to the small amount of grazing taking place here. The forest thins out on the northern aspect of the kotal above the Zgumiser Valley, but again appears clothing the southern aspect of the Sikhan kotal, which is immediately above Zgumiser. The height growth naturally varies greatly over the area owing to the fact that the trees are growing at elevations differing in the extreme cases by some 2,000 feet. Trees of 10-12 feet girth were measured in places.

It was noticeable that dead trees were by no means so plentiful as at Shinghar. This, whilst to some extent due perhaps to the fact that fellings are made in this forest, is also in part the result of the bark beetles' attacks being apparently on a smaller scale here than in the neighbouring area.

The undergrowth is of much the same nature as that at Shinghar.

Treatment.

Management of the Forest.—The same remarks apply to this area as have been already given for Shinghar. There is not, however, so far as I am aware, any forest staff at Sherghali as yet, and no serious attempt at forest management has been undertaken. The Political Agent spent some time here during the summer (1905), having a small standing camp at Sherghali village; this is the first time that such a departure has been attempted, the Sherghali locality being notorious as a centre for outlaws and the unsettled members of the tribe. Colonel Trench was able to discuss the question of forest reservation and future management and protection with the maliks during his visits. The lines proposed are the same as those laid down for Shinghar, and the malik, Sahib Khan, and his adherents who hold sway at Sherghali state that they would have no objections to the proposals being carried out provided that the posts of guards and beldars were given to their people. The collection of the seed would be a question for subsequent consideration. One guard and two beldars is the proposed scale for the present.

Grazing takes place to a certain extent in the forest and requires, if it is not possible to stop it entirely, some restriction in order that natural regeneration may be obtained in the blank areas and the open parts of the forest.

The attacks of the beetle pests are not so serious as at Shinghar, and this furnishes a very strong reason for taking action at as early a date as possible. If infested trees are cut out now, whilst their number is small, it is probable that it will be possible to stamp out the pest at a small cost. Since many of these trees will be saleable (and there is no reason why the timber should not be sold provided the logs are *first barked* and *all the bark burnt*, *all the branchwood* and *tops being likewise burnt*) the expense incurred in the work should be recoverable.

Forest Operations.—Fellings.—The Sherghali Forest is, comparatively speaking, easy of access, and could be easily rendered so for the export of forest produce. The forest is within five marches of Dera Ismail Khan. Permission has been given to the felling of dry trees here, the wood being taken to Fort Sandeman and Dera Ismail Khan. It is, however, open to doubt whether only dry trees are removed, or rather whether they have not been rendered prematurely dry in the forest. It is, of course, against the interest of the tribesmen collectively to cut green trees, since to do so diminishes their seed yield, but it is, I think, not impossible that individuals would be prepared to stand in with the contractor and ring trees in accessible spots. Since there is no forest staff to superintend the cutting, or forest officer to mark the trees to be removed, it is more than probable that this has been the procedure in the past.

Collection of Chilgoza seed and minor produce.—The same remarks apply as given for Shinghar.

Future Treatment.

Boundaries.—The first steps to be taken are, of course, to come to an agreement with the Sheranis, lay out the boundaries on the ground, and strictly, or so far as is possible, close the forest to grazing.

Management.—The same remarks apply as given under Shinghar. The Political Agent, I believe, suggests that a trained forest officer should be stationed at Sherghali all the summer months to manage this forest and Shinghar. A bungalow would be erected near the Sherghali village. Water is available here and supplies could be obtained from the villagers all the summer months. There would be a considerable amount of work at Sherghali. Since the forest is accessible all dead trees could be sold, and one of the first steps to take would be to mark down and extract all trees infested with bark beetles. When this operation had been completed, the extraction of the dead trees (which the beetle does not touch, and which can be left in the forest without harm until the first operation has been carried out) can be proceeded with.

The extraction of the timber would, however, be but a part of the duties. The sowing and planting of blanks, opening out of forest paths, and the superintending of the collection of the Chilgoza seed would also occupy considerable time. With reference to this latter the same remarks apply to the rights of the tribesmen as have been already discussed for Shinghar.

SPIRAGHAR FOREST.

Mr. Elliott visited this forest, which is situated in the north-west of the district, in the winter of 1892. I have not myself seen the area. The forest occupies the Spiraghar Range, and, according to Mr. Elliott, there are miles of fine Chilgoza forest with, on the lower slopes, pistachia, olive, and ash. He suggested using this forest by dividing it into two portions, over one of which the neighbouring tribes would be allowed to collect the seed, whilst the other was taken in hand by Government with the object of ensuring natural regeneration. This suggestion has not been given effect to, and the area at present is in much the same position as Sherghali, save that no steps have, I believe, been taken with regard to reservation proposals.

VIII.—The Takht-i-Suliman Forests.

The forests to be considered are those on the Takht itself and its lower slopes, all situated to the east and south of Maidan, and the forest on Maidan and the Kaisaghar ridge.

Situation and Configuration.

The Takht or Takht-i-Suliman, as it is called, in contradistinction to its twin ridge, the Kaisaghar, is a bold ridge forming the northernmost end of the Suliman Mountain Range on the east (*cf.* map). On its southernmost extremity this ridge consists of four flat-topped peaks, its northern portion being of a maidan-like nature dropping slightly northward. On the north the mountain is very precipitous, whilst the east is a sheer precipice dropping several thousand feet to the foot hills above the Derajat plains. The western and southern slopes, although steep and rugged, have comparatively easy slopes for this part of the world and are clothed with Chilgoza forest which covers the spurs and fills the valleys and glens. The upper few hundred feet of the western face of the Takht ridge form a vertical wall, bare of vegetation, which is succeeded on its lower edge by a smooth-faced sloping glacis clothed with scattered vegetation and a few Chilgozas. The southern portion of the western side drops into the Torgai nala which debouches into the great Obo-khel Dhana. South-west of this nala are series of low rocky ridges with an east and west trend, covered with Chilgoza. The route to the Takht from the south after winding over bare ridges from the Sikhan kotal passes through this Chilgoza forest. The northern portion of the western face of the Takht ridge drops steeply down to join Maidan, the elevated plateau which separates the Takht from its twin parallel ridge, Kaisaghar. The topography of Maidan has already been described. It sweeps up on its western edge (*vide* pl. 6) into Kaisaghar, whose eastern face is cut up by a parallel series of nalas into a number of rugged ridges having an east and west strike, as shown in the photograph. The forest in the right hand of this picture is on the Takht slope; the southern and central portions of Maidan are seen in the middle distance with the Kaisaghar ridge to the west. To the north both Maidan and Kaisaghar drop precipitously to the valleys below. To the south the former falls away in slopes of an easy gradient to the Torgai nala, elevation 8,200 feet, the actual ascent out of the nala being by a curiously built bridge. In order

Photo.-Mechl. Dept., Thomason College, Roorkee.

Photo. by Lt. O. H. B. Trenchard R. E.

THE MAIDAN PLATEAU

The chilgoza-covered lower slopes of the Takht-i-Suliman in the foreground,
and the Kaisaghar ridge in the background.
The forest on the lower half of Maidan is clearly shown.

[To face page 24.

to understand the relative position of these forests with reference to those of Shinghar and Sherghali reference should be made to the map of the locality.

Leaving the Sikhan kotal we marched north over a shoulder connecting the Takht Range with the north-west corner of Shahdur through scattered Chilgoza forest. These trees grew less and less as we advanced, and at last there was no forest in the true sense of the term. We marched over a succession of rocky kotals and finally dropped into a small valley where forest was again met with. Climbing up over a densely wooded slope we dropped down on the other side into a little cup-shaped dell beyond which, over a rocky, sparsely-clothed kotal, we reached Camp Gardao in good forest. This place is just above and to the south of the Torgai nala.

Area.

Owing to the scattered nature of some of the forest and the extremely rugged nature of the ground it is difficult to form an estimate of the area occupied by these forests. The Maidan tableland has been estimated at about 4 to 6 miles square, but our observations seemed to show that this estimate was a low one. Including the forests on the Takht and Kaisaghar, taking the crest of the former as the eastern and the western foot of the latter as the western boundary (see map), the area is roughly estimated at 46·4 square miles; this area, however, is only approximate and includes sparsely clad portions of ridges and valleys.

Boundaries.

The boundaries of the tree-covered area are fairly simple on three sides. On the north the northernmost edges of the Maidan plateau and the crests respectively of the Takt and Kaisaghar. To the south the boundary would more or less follow the edge of the forest being carried in as straight a line as possible, outlying scattered trees being left out of account and treeless areas being included if they thereby straightened the boundary line.

Forest Growth.

The species occupying the ground is principally Chilgoza with here and there in parts patches of blue pine or scattered trees of this species.

The Chilgoza Forest.—From the boundary of the North-West Frontier Province (Dera Ismail Khan District) at Sikhan kotal to just south of Camp Gardao the Chilgoza Forest consists of scattered trees only. Two miles east of Sikhan, at Camp Scallon, however, there is a small patch of Chilgoza forest, and this trends down the hillside in a more or less scattered fashion to the Obo-khel Dhana. In a ravine on the way from Sikhan to Gardao there are also a few large blue pine trees. The forest proper, may be considered to have been reached at Gardao. This place is a camping spot occupied in the summer by graziers, wood-cutters, and pilgrims to the shrine on the Takht. A fine piece of Chilgoza forest surrounds this spot, some of the trees measured girthing 9 feet and upwards. The forest is uneven-aged with a number of young trees present. The Chilgoza continues down into the Torgai nala, the trees growing scantier. To the north and east of this nala the growth becomes denser, clothing the lower southern approaches of Maidan (some blue pine is also present here) and the lower slopes of the Takht with a fine dense forest of pure Chilgoza. The slopes of the Takht are intersected with ravines running east and west, and on the crests of the intervening ridges the trees are more stunted and spreading ; but in the ravines fine forest is met with, and this continues for some 2,000 feet up the sides of the mountain to the glacis. Here at an elevation of about 10,000 feet the trees abruptly thin out, the Chilgoza on the glacis being much scattered. An examination showed, however, that this glacis had in parts been formerly much more thickly clothed with the pine, for large stumps of as much as 12 feet girth were noted. At the top of the glacis, as has been said, the mountain rises to its crest in a sheer wall devoid of all vegetation.

Turning now to Maidan, I have shown that the southern approaches are covered with a mixed forest of Chilgoza and blue pine. On reaching the southern edge of the plateau pure Chilgoza is again met with. It has been reported, and the statement is in print in several places, that the forest on Maidan, or the chief species present, consisted of the blue pine. It would appear that this statement is the result of observations made on the lower approaches of the plateau only, although it is not in accordance with facts even there. My observations showed that the plateau itself is covered with a pure Chilgoza forest, very dense in its northern upper half, but more open and park-like towards the south (*vide* pl. 6). In this southern half are two open spaces, in the larger of which are some huts and a small depression or pond which contained a little water at the time of our visit.

Natural Regeneration.—This is particularly good in many places on the Takht which, owing to its inaccessible nature, is probably little grazed over except on its extreme lower slopes. Beneath the large trees still standing at the foot of the glacis, and round the stumps of other recently felled ones, examples of excellent advance growth occupied the ground. In some cases this growth partook of the nature of thickets of young trees up to 15 feet high.

On parts of Maidan natural regeneration is also of a good quality and abundant. In others, however, badly shaped trees and bare places speak only too eloquently of the presence of grazing animals.

The Blue Pine.—Nowhere on the Takht or Maidan can this tree be said to form a forest. It is found either in little groups amongst the Chilgoza or scattered in single trees. The presence of the tree and the peculiar way in which it is met with is somewhat perplexing. The pine is first seen in a ravine on the road between Sikhan ziarat and Gardao where a few fine examples are present. It is next encountered in the Torgai nala, below Gardao, and in its tributaries or upper reaches higher up towards the Maidan plateau. In the nala its growth is extremely fine, trees of 13-14 feet girth and over 90 feet in height and more with straight clean boles scarcely tapering to half way up being met with. On the lower slopes of the Takht and the southern approaches to Maidan the tree is found mixed with Chilgoza, but here it appears to be invariably in clumps. Climbing up the Takht it is next met with as scattered trees only on the glacis. On the Maidan portion of the top of the Takht blue pine are present. Their height growth is not great, but they have a good girth. They are not cut, being held sacred owing to their neighbourhood to the shrine. Blue pine are also present in clumps in the ravines between the four small tops forming the southern portion of the Takht crest. The eastern face of the ridge is a sheer precipice of many thousand feet, but wherever possible scattered blue pine trees are to be seen clinging to the precipice face. Far below an examination through the glasses showed that the foot hills stretching to the north and south, as seen from the little ziarat in the precipice face, appeared to be clothed with this species. The tree is not present on the Maidan proper, but appears again in some abundance on the much cut-up eastern slopes of Kaisaghar (*cf.* pl. 6). Eastern aspects and ravines appear to be its favourite locality in these mountains.

Natural Regeneration.—A considerable amount of young growth of this species was noticed, both in the mixed forest and in the neighbourhood of scattered trees in the ravines, so it evidently seeds well in this locality.

The presence of the Blue Pine and the Water-supply.—There is another point besides its distribution which provides food for reflection, and that is the presence of this tree in what is accepted as an absolutely waterless tract of country. In the Himalaya the blue pine grows amongst the deodar and oaks and undoubtedly requires a certain amount of water in the soil. How is it then that it manages to exist in this so-called waterless region? This question of water on Maidan and in its neighbourhood will be discussed briefly later, but the presence of this tree is a significant factor in the problem which it is difficult to ignore.

The undergrowth on the area consists of hawthorn, sweet brier, gorse, etc.

Treatment.

Management.—This forest is, at present, entirely in the hands of the sections of the Sheranis living in the neighbourhood of the Takht-i-Suliman. As will be understood, therefore, in the absence of a professional staff or advice as to the best means to be taken for its maintenance, the forest growth is deteriorating. In the absence of any form of protection the forest is suffering from—

(*i*) Grazing, although this does not appear to be as intense as has been the case at Shinghar.

(*ii*) From the bark-boring beetle pests present at Shinghar and Sherghali. The discovery of the presence of these insects in the Takht forests forms, perhaps, the *strongest* reason for some steps being taken in order to ensure their protection. The beetles' habits are now well known. All the dead Chilgoza trees inspected on this area had died, either directly (in the greater number of instances) or indirectly, through the attacks of this pest. The discovery of the insects here has shown that they have infected the whole area occupied by the pine in this region, and my observations seem to prove that the source of infection has been Shinghar,* and that it has spread from there to Sherghali

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* I cannot speak for Spiraghar. Shinghar may have been infected from Spiraghar, but owing to the distance intervening I think it is improbable.

> and from the latter place to the Takht and Maidan forests. I have shown that at Sherghali it is not as abundant as at Shinghar, and it is, I think, probably less abundant on the Takht and Maidan than at Sherghali. There is, however, no question as to its presence. Its great powers of multiplication and the damage it is capable of effecting have been already demonstrated in my monograph on the insects.

It is a fact that it would be difficult to dispute that the rivers and springs issuing from this part of the Takht Range are dependent to a great extent on their catchment areas being maintained under trees. It would, therefore, seem to be imperative that protection of some kind should be afforded to this fine forest and an effort at any rate be made to stamp out the beetle pest. It will be of little use undertaking this work at Shinghar and Sherghali if the pest is allowed to wax in numbers unchecked in the Takht area, for it will always be able to re-infect the other forests from there.

An examination showed that the Chilgoza beetles do not infest the blue pine (with the exception probably of *Pityogenes coniferæ*, which is only a branch pest). In this latter tree, however, species of *Tomicus* and *Polygraphus* were discovered, which are closely allied to or identical with the species found attacking the blue pine in the North-West Himalaya.* This discovery is of considerable interest.

Forest Operations.—Fellings.—An examination of the forest round Gardao, on the slopes of the Takht up to the glacis, and on the glacis itself and on Maidan, showed that a certain amount of felling work is undertaken by, or allowed by, the Sheranis within this area. The trees are felled with the maximum waste of wood possible. Stumps of several feet in height containing a considerable amount of valuable timber are left. The stem of the felled tree is hacked up into beams in the crudest manner, no saw or even proper axe being employed. Or the waste may be greater still. *E.g.*, near the foot of the glacis a Chilgoza of some 11 feet girth, a fine, tall, straight tree, had been recently cut down. From the lower portion of the butt a log had been hacked off and then roughly dressed into a square mass of wood of about 4 by 3 feet by 8 inches, apparently for use as a door or to serve some such purpose. The whole of the rest of this log lay about in great chips, wasted. The rest of the tree had not been made use of. In a country where wood has the value it has in this part of the world, and where for climatic reasons alone the forests require strict preservation, this method of felling would seem to be deplorable and to require some form of regulation.

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* *Vide* Departmental Notes on Insects that affect Forestry, No. 2, pp. 221-245.

Collection of the Chilgoza seed.—This is undertaken on the lines described under the Shinghar Forest.

Collection of minor products.—Resin.—I noticed some Chilgoza trees near Gardao tapped for resin. A horizontal cut is made into the tree about 5 inches or so deep and 6 inches to 8 inches broad. An inclined cut is then made from 8 inches to 10 inches above the horizontal one and carried down at an angle of about 60 until it meets the horizontal one. The resin takes some days to ooze out into this nick. The exudation is used, so the maliks informed me, for putting on to wounds to prevent the attacks of insects at the sore. I was informed that the practice of tapping was not a common one. Nevertheless I noticed a not inconsiderable number of trees which had been treated in this way.

Branchwood.—Chilgoza branches are broken off the trees and used to make temporary shelter huts for graziers, resin tappers or wood cutters, etc. One such newly built hut was seen in the vicinity of a freshly tapped tree of some 8 feet girth. A few branches are stuck upright in the ground and other branching ones are interwoven in between and interlaced over the top. These branches are also used by the graziers to form sheep pens to herd sheep and goats in at night at the grazing encampments.

Future Treatment.

As I was unable to meet the Deputy Commissioner of Dera Ismail Khan, it is difficult to deal with the question as to what future treatment or form of protection it will be possible to give the Takht Forests. Any suggestions that could be made would be on the lines already mentioned for the Shinghar and Sherghali Forests. The three most important points which present themselves are:—

(*i*) Prevention or localisation as far as possible of the grazing in order to help the forest in its efforts to naturally perpetuate itself.

(*ii*) The marking down, felling, and burning (at least the bark of the trunk and all the side branches and tops) of all trees infested with the Chilgoza beetle pests.

(*iii*) Restriction of fellings to the blue pine and dead Chilgoza trees, and, if possible, the regulation of such cuttings.

(*iv*) An arrangement by which a certain proportion of the cones would be left upon the trees in order to ensure natural regeneration being obtained on those areas which are at present entirely blank.

(*v*) If feasible a rough demarcation of the area ot these forests should be made.

Note on the Water-supply on the Takht Range.

A difficulty which has always faced expeditions to the Takht-i-Suliman Range and the Maidan plateau has been the apparently total absence of water on these hills. In May 1905 the Government of the North-West Frontier Province sent up an expedition under the command of Major (now Lieutenant-Colonel) H. V. Biggs, D.S.O., R.E., to search for water on Maidan in the hope of being able to form a hill station there. The expedition started from Draband, marched up by the north face of Maidan, spent a day on the plateau (using themselves snow found lying there) and, failing to discover water, returned to their starting point down the Obo-khel Dhana. The expedition did not ascend either the Takht or Kaisaghar ridges. Major Biggs in his report gave it as his opinion that there was no water to be found in the neighbourhood.

Whilst at Camp Sungar Scallon, two miles due east of Sikhan ziarat, our party discovered a small spring in the extreme western corner of the precipitous face of Shahdur in the angle made by its juncture with a much lower small spur which runs due north. The presence of this water had seemed probable owing to the fact that there were numerous chukor about, a bird which requires water daily.

I have noticed the distribution of the blue pine, a tree which requires a certain amount of water. It is present in the ravines and also on the Takht and Kaisaghar. It is, I think, quite possible that the explanation of the presence of this tree may be due to the fact that water exists near the surface, perhaps caught in depressions and pockets in the limestone formation, after percolating through fissures and channels eaten out by it during the heavy storms the neighbourhood appears liable to and at the time of the melting of the snows. In the banks of the Torgai nala ivy and various small plants pertaining to non-waterless soils were noticed, and whilst collecting botanical specimens in more than one place it was possible to dig the fingers into a soil which was full of moisture.

With such evidence it is not possible, I think, to state with any certainty that the area is as waterless as has always been supposed. It would probably require a certain amount of time to discover water, but its absence can scarcely be considered to have been proved. Little faith can be placed in the assertion of the Sheranis that water is entirely absent. It would be interesting to know where the considerable community of graziers, wood-cutters, and pilgrims who evidently occupy Maidan and the neighbourhood (at Gardao and elsewhere) during the summer months procure their water from. The community can scarcely be of such a nomadic description that no man spends more than one night upon Maidan or in the neighbourhood. Snow and collections of rain water are of course available in the spring, but it is doubtful whether this supply lasts through the summer months. The search for water was not a part of the programme of our visit and no time could be given for such an object. Nevertheless it would have been a most interesting quest and would explain several points about the fauna and flora of the Takht at present shrouded in darkness.

It may be noticed that chukor were fairly plentiful on the mountains, both on the lower slopes of the Takht and in places between Sikhan ziarat and Camp Gardao.

The value of these Forests from a military point of view.

Although the writer does not possess the knowledge requisite to make any statement upon the value these forests would have in the event of military operations upon a large scale being undertaken on this frontier, it would, perhaps, not be out of place to draw attention to this aspect of the question. To a large standing base they could scarcely prove otherwise than an invaluable boon.

APPENDIX.

Countings of Chilgoza seed made by Bhai Sadhu Singh, Extra-Assistant Conservator of Forests in Baluchistan.

Counting on the 16th June 1905.

No.	Girth of trees.		Cones.
	Feet.	Inches.	
1	3	8	105
2	7	0	63
3	5	0	72
4	3	8	10
5	3	0	1
6	3	3	6
7	3	7	3
8	3	5	44
9	4	0	4
10	6	0	38
11	7	6	120
12	7	2	40
13	2	6	66
14	4	6	120
15	1	2	4
16	1	3	12
17	2	2	30
18	1	1	20
19	2	3	23
20	8	4	400
Total . . .	80	6	1,181
Average . . .	4	0	59

Twenty cones gave 720 seeds.
Average seeds per cone 36.

Counting on the 17th June 1905.

No.	Girth of trees.		Cones.
	Feet.	Inches.	
1	5	6	15
2	2	7	29
3	2	0	20
4	1	6	12
5	3	6	16
6	2	0	30
7	4	6	32
8	5	4	25
9	2	0	60
10	3	0	36
11	6	2	10
12	5	4	35
13	5	1	50
14	7	4	14
15	7	1	120
16	6	9	150
17	7	2	75
18	8	1	240
19	3	8	8
20		6	1
Total . . .	97	1	928
Average . . .	5	10	46

Twenty cones gave 612 seeds, *i.e.*, 30 seeds per cone.

Counting on the 19th June 1905.

No.	Girth of trees. Feet.	Girth of trees. Inches.	Cones.
1	6	1	214
2	5	9	69
3	5	2	67
4	8	0	145
5	6	0	154
6	5	3	66
7	3	6	7
8	4	4	141
9	2	6	52
10	4	3	108
11	6	3	117
12	4	7	210
13	5	7	80
14	5	3	37
15	3	5	48
16	7	0	93
17	9	2	200
18	6	0	168
19	7	4	40
20	4	4	18
Total . . .	109	9	2,034
Average . . .	5	6	101½

G. I. C. P. O.—No. 182 R. & A.—18-10 1906.—500. J. W. D.

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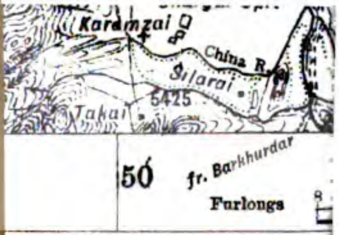

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1	Shinghar
2	Sherghali
3	Takht-i-Suliman

Forest Bulletin No. 8 1906.

A NOTE

ON

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OF

HOPLOCERAMBYX SPINICORNIS

(THE SINGHBHUM SAL BORER.)

BY

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A NOTE

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LIFE HISTORY OF HOPLOCERAMBYX SPINICORNIS

(THE SINGHBHUM SAL BORER).

I.—Introductory.

BETWEEN the years 1896-1898 some heavy sleeper cutting operations were undertaken in the almost virgin Sal forests of the Singhbhum District which is situated in Chota Nagpur. This district and adjacent areas in Native States and the Central Provinces may be said to be, or to have been, the home *par excellence* of the Sal tree in India. With a soil and climate particularly suitable to its requirements in these respects the tree attained a prodigious size in the small riverain terraces of the valleys situated amongst the mass of rocky trap-covered hills which form the configuration of this part of India. The history of the sleeper cutting operations in these magnificent Sal forests has never been written outside of purely Government reports and returns and it is a pity that such should be the case since it would have resulted in the compilation of some valuable statistics on what were at the time little known localities and forests.

During the first half of the year 1897 the writer was in charge of the sleeper works in Singhbhum and on February 1st obtained from one of the sleepers a full-grown larva of what was evidently a Cerambyx beetle. Later on in the year it was noticed, whilst the sleepers were being passed and taken over by the railway engineers, that a certain proportion were marred by the tunnels of a boring insect; so badly so in some cases that the passing authorities rejected them solely on the account. These galleries were attributed at the time to grubs identical with the one found in February. It was noteworthy also that the sleepers so affected came in most instances from the same blocks of forest. During June beetles began to issue from the holes in the sleepers and it was then discovered that the surmise made in February was the correct solution and that the pest was a *Cerambyx* beetle. Whilst on privilege leave later in the year I had this insect identified at the British Museum as *Hoplocerambyx spinicornis.*

II.—Observations made on the Life History in Singhbhum.

The heavy divisional and additional sleeper work in Singhbhum during the first half of June 1897 left no leisure for anything outside it, but I was able to subsequently put together the rough notes I had jotted down from casual observations made in the forests and depôts. These were published in my *Injurious Insects of Indian Forests,* pages 71—73, being the first recorded observations extant on the life history of the insect in India. Avowedly rough as they were they established the following points :—

(*a*) Full grown larvæ were to be found in Sal timber in February.
(*b*) Pupæ (half mature) were to be found in the pupal chambers in the wood in the middle of March.
(*c*) The beetles were to be found on the wing from towards the end of May throughout June and on into July.
(*d*) The beetles couple during June and July.
(*e*) That the insects caused the most serious damage to Sal timber, their tunnels going right into the heart of the tree and that this damage was at times so extensive as to lead to the rejection of sleepers on this score alone.

Owing to a transfer the writer has had no opportunity since of continuing the study of the life history of the insect and no further record of it appeared between 1897—1904.

III.—The discovery of the Insect in the Balaghat Sal Forests, Central Provinces.

In the cold weather of 1905 a communication was received from the Inspector-General of Forests to the Government of India to the effect that whilst on tour in the Balaghat Forests in the Central Provinces he had noticed some fine large green Sal trees apparently dying under the attacks of an insect. The trees appeared to be suffering so severely that the infestation was at once considered of very considerable importance and instructions were issued by the Inspector-General that an investigation of the matter should be carried out at an early date in order to determine the exact cause and manner of death of the trees.

In accordance with the instructions received Mr. A. P. Percival, the officer in charge of these forests, examined during April areas of Sal trees which were attacked by the pest and were evidently dying under this attack. From the trees he secured some larvæ, nymphs and beetles which were forwarded to me and identified as the Singhbhum Sal Borer (*Hoplocerambyx spinicornis*).

From the valuable observations made by Mr. Percival on the insect, corroborating the previously-published observations in all points and considerably adding to them, and the excellent series of parts of infested trees sent it is now proposed to give in detail the life history of this pest, probably the most serious the Sal tree has to contend with in the Central Provinces and Chota Nagpur areas, and to make some remarks on methods of endeavouring to protect unaffected forests from its attacks and of getting rid of it from seriously infested areas.

IV.—Description of the larva, pupa and beetle.

Larva.—Elongate, tubercular, with a squarish section, consisting of 12 segments.

Head black, transverse, with powerful mandibles. The segment following the head (the prothorax) is greatly enlarged, dark yellow in colour, with a dorsal shining plate of thicker consistency than the rest of the body; the following two prothoracic segments are narrow. They and the other nine segments of which the body is composed are yellow in colour. There are two prominent elevations or tubercles placed transversely on the dorsal surface of segments 4 to 10 inclusive. The 12th segment tapers to a blunt point behind. There are a pair of minute legs on each of the thoracic (1st 3) segments and a pair of short sucker-feet on each of the segments 4 to 10, being most prominent on segments 7 to 10. Length of full grown larva 3½ inches; size variable. Plate I, figures 1, 2 show a two-thirds grown and fully grown larva.

Pupa or nymph.—Whitish yellow in colour. Exhibits the form of the perfect insect in part. The head is however pressed down upon the upper part of the chest upon which, below it, are folded the legs and the rudimentary wings, the latter being curved round so as to lie in this position. Seven abdominal segments are visible on the dorsal surface of the nymph. The antennæ are curved backwards and lie pressed against the sides of the insect. Length 2 inches; variable in size. Plate I, figures 3, 4, 5 show side and ventral views of female pupæ.

Beetle.—Black or a dark chestnut-maroon colour, scarcely shining.

Head large, prominent, much sloped forwards, channelled and ridged on the upper surface. Mandibles stout, black. Antennæ black, shining, except last 4 joints which are dull and yellowish brown. Eyes kidney-shaped, placed behind and around the antennæ.

Thorax rather longer than broad, constricted in front, where there is a "collar" consisting of two traverse ridges with a channel between them. This collar is repeated on the basal margin, but is not so well defined, the lines being wavy. The thorax is covered with a series of wavy, transverse, prominent ridges which are interrupted in the centre by a small longitudinal shining black area with two smaller ones placed on either side and below it.

Elytra elongate, broader at base than thorax, with well marked shoulders with a depression just behind them. Surface smooth with here and there slight depressions and a faint longitudinal costa. Apex terminates in two spines, a sutural and median one. Elytra are slightly paler in colour towards extremity; under surface and legs shining black.

The ♀ differs from the male in having the antennæ much shorter, reaching not quite to the extremity of the body. Otherwise they resemble in build those of the male.

Length ♂, 1½ to 2⅛ ; 1⅝ to 2¼ inches.

Figures 6 and 7 show a dorsal and side view of beetle, figure 8 a dorsal view of male.

Several specimens sent me from Balaghat were a light maroon or chestnut yellow in colour. These had evidently been taken from the pupal chambers in the trees the insect being in the resting stage and not quite ready to issue.

V.—Life History.

The points ascertained about the life history in 1897 have been already detailed above.

Mr. Percival has since established the fact that young larvæ, less than half an inch in length, are to be found in the trees in November. Also that larvæ are to be found throughout the year. These are important data as they practically settle the point that the grubs spend more than one year in this stage of their existence and that therefore the insect takes at least two years to complete its life cycle from egg to beetle.

Mr. Percival has established two other important points—

(i) The grub commences operations from the outside while small and after boring as far as the cambium works up and downwards in a zig-zag course through the wood.

(ii) Living beetles were taken from cut timber which had been lying in depôts far from any Sal forest for more than a year.

(iii) Pupæ were also found in the heart-wood of timber in a similar position.

With these additional data to work with, the life history of this insect, save in the one particular as to the exact time spent by the larva in the wood, becomes comparatively easy to detail. Even in the particular of the period of time passed in the grub stage the writer has little doubt but that the period given below will be found to be approximately the correct one.

Egg.—This is the only stage about which we have at present no record. This is not a matter for surprise since it is exceedingly difficult to discover the eggs of most of the Coleoptera. In a recent analogous case, that of the 'Quetta Borer,' a Cerambyx beetle allied to the one under consideration, the writer had exceptional facilities for discovering the eggs. In this case the female beetle deposits her eggs at wounds on trees from which the sap is oozing or herself bores down through the bark until she reaches the sappy layer beneath in order to place them in a suitable position. This procedure is rendered necessary owing to the fact that the young grubs on hatching out are very small and their mandibles are quite soft and quite unfitted for boring into wood or hard bark. It is most probable that the Singhbhum Sal Borer beetle acts in the same way and lays its eggs in June, July either at wounds in the Sal trees or grooves down through interstices in the bark in order to deposit them in the sappy cambium layer.

Larva.—We have no information at present about the young larval stages below ½ an inch in size. On hatching the young grubs probably live in the soft cambium layers until their mandibles are sufficiently stout to enable them to penetrate into the outer sap-wood. As soon as the latter is the case they commence to hollow out broad irregular galleries between the sap-wood and cambium, entirely consuming the latter and making large shallow depressions in the former. These galleries have a general direction in the long axis of the tree. As the grub increases in size so do the galleries and they go deeper and deeper into the sap wood (*vide* Plate II). From our present information it would appear that the grubs live for considerably more than a year in this stage of their existence. We know that the beetles appear in June and July and pair during these months. Assuming that the eggs hatch out within a comparatively short period, as has been proved to be the case with other allied species, the young larvæ will appear in July, August. In November they are still less than half an inch in length and larvæ, presumably of all sizes except the newly-hatched ones which are only found in July and August, are present in the trees all the year round and full grown ones 3 inches in length in February. Now a larva which was only half an inch in length in November could not grow to 3 inches by the end of January in the cold months of the year and therefore the point seems to be established that the grub spends about a year and a half in this stage. The full-grown larvæ are found in the heart-wood or on their way there. An examination of a number of galleries made by full-grown grubs has shown that the tunnels into the heart-wood are always more or less constant in appearance and size and always end in the pupal chamber. They curve away from the inner sap-wood and outer edges of the heart-wood, where the grub has been feeding up to then, in a zig-zag manner in the long axis of the tree, either slightly upwards or downwards but always inwards and are invariably made by the full-grown grubs. These facts establish the point that the feeding operations of the grub commence in the cambium, continue between the cambium and sap-wood and are subsequently carried into the sap-wood and outer layers of the heart-wood; but that the grub only undertakes the work of boring into the inner heart-wood when it is full-grown, has done feeding, and wishes to pupate. The more or less horizontal gallery penetrating the heart-wood is of much larger diameter than the larva making it and is usually free from the wedged mass of chewed wood which has passed through the larval body and tightly packs the galleries in the sapwood and outer heart. When the grub has reached the hard inner heart, the distance it penetrates being very variable (*vide* Plate III), it carries the tunnel in an upward direction usually, although not invariably, parallel with the long axis of the tree. This portion of the tunnel is about 4—6 inches in length, narrow-elliptical in shape and forms the pupal chamber of the insect. When the chamber is complete the grub backs down the tunnel until it reaches the broad horizontal portion, when it turns round and backs into the pupal chamber again. The lower end of the chamber is then closed with a curious calcareous covering. The tunnel is lined with the substance for an inch or more and then the material is carried over so as to entirely close the pupating chamber. When looked at from above this partial cocoon has the appearance of a Brazil nut, it having often a flattened-out keel-shaped edge. The covering is white in colour and very fragile. Its object is almost certainly the protection of the pupa, since the large gallery made by the larva is so often in direct communication with the outside when the grubs are at all numerous in the tree. Having completed this covering the grub then eats out the edges of the chamber immediately below the calcareous lining and fills the portion of the gallery below the cover with the particles of wood so obtained. The larva is then ready to pupate.

It is probable that the grub is full-grown at the beginning of the second cold weather after it has hatched from the egg and that it commences to tunnel into the hard heart-wood about November of that year, completing the pupal chamber and pupating towards the end of January and beginning of February. The period will of course vary by a week or two since the beetle is to be found itself on the wing during a period of some six weeks or more.

Pupa.—The insect would appear to spend some three months in the pupal stage or in the pupal chamber; from about the middle of February to the middle or end of May. Half formed pupæ have been found in the middle of March and a nearly formed beetle in April. The beetles taken by Mr. Percival in the latter part of April, and forwarded to me, were, with one exception, fully formed but with their outer parts still soft and light coloured. They were in the resting stage. It is probable that some two months are actually passed as the more or less white soft nymph depicted in figures 3, 4 and 5 and a month as a beetle resting whilst its outer parts harden.

Beetle.—Beetles commence to emerge towards the end of May and on through June into July. To leave the pupal chamber they break through the calcareous covering and crawl up through the larval gallery, either finding an exit at the upper end which is in the sap-wood or forcing their way through the packed wood refuse which has replaced most of the wood or boring their way out through the sap-wood and bark to leave the tree. On arriving at the outside the insects probably couple within a few days and the male then dies, whilst the female sets about finding a suitable tree or trees to lay her eggs in. The exceedingly important factor as to the number of eggs laid by the insect has still to be ascertained as also the point as to whether she lays them all in one tree or upon several.*

Mr. Percival has mentioned the fact of having found pupæ and beetles in the interior of cut timber which had been lying in depôts far-removed from Sal forests for over a year. This observation is explained by the fact that once the grub has approached full size and got down into the interior of the wood the removal of that wood from the forest would not in any way affect its development into the nymph and beetle stages. Only in cases where the timber was exposed to a very powerful sun would there be a likelihood of the larva being killed off at this stage. This does not however mean that the beetle would lay her eggs in cut timber. Green cambium is a necessity to the young larva and the egg will always be laid in living and, where possible, sickly standing trees or, probably, in newly felled green ones.

It was noted in 1897 that the beetles make a comparatively loud stridulating noise by rubbing the dorsal edge of the posterior portion of the prothorax over the outer dorsal edge of the anterior margin of the metathorax. Their mandibles are very powerful and they use them freely in self-defence when annoyed and interfered with.

I append the diagrammatic table of the life history of this insect I prepared in 1897. It will be seen that there is no reason to alter the forecast then given of the probable life cycle of the insect except that we now, from Mr. Percival's observations, can with almost certainty fill in the uncertain period as to the length of time spent in the larval stage. In the former table I considered it as most probable that the life cycle would exceed a year.

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* The Quetta Borer, before alluded to, lays 50 eggs in clusters of 8—10 each. These may be deposited on the same tree or upon several, but more than one cluster is never apparently laid at any one spot.

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1897 . .					†	†††† ...	†††- ...	----	----	----	----	----
1898 . .	----	----	----	----	----	----	----	----	----	----	□□□□	□□□□
1899 . .	□□□□		●●●●	●●○○	○○○†	†††† ...						

Explanation—

† = Egg stage.
•
— = larval or grub stage passed in the bast and outer sap-wood.
□ = larval stage passed in heart-wood.
● = Pupal stage.
○ = Fully formed beetle but with outer parts still soft, resting in pupal chamber.
† = Mature beetle.

VI.—Damage committed in the forest.

From the above account of the life history of this insect it will be obvious that it is capable of proving a most serious pest in the Sal forests under consideration—probably one of the worst at present known.

The actual damage effected is committed by the grubs. That by the beetles is almost entirely confined to the propagation and increase of the species by egg laying.

The grub is dangerous in two ways—

(i) It feeds in and kills off the cambium layer of the tree and thus kills the tree itself.

(ii) It tunnels into the heart-wood and thus ruins it commercially.

In these performances this insect is at present an exception to the general rule. Many forest pests, such, *e.g.*, as the bark-boring *Buprestidæ* and *Scolytidæ*, kill the tree by infesting and feeding upon its phloem. The wood is, however, left untouched. Others may, as has been shown in the case of the bee-hole borer of teak,* *Duomitus*

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* *Vide* Note on the "Bee-hole" Borer of Teak in Burma, p. 15, Calcutta (1905).

ceramicus, tunnel into the wood (to pupate) and ruin it as timber without killing the tree in so far as at present known.*

From the life history we have already considered it will be evident that *Hoplocerambyx spinicornis* is far more dangerous when present in any abundance in a forest. When in the numbers discovered in Balaghat by Mr. Percival, and doubtless the same has been the case in Singhbhum owing to the large increase of the insects occasioned by the heavy sleeper works of 1896—98, the insect has a two-fold power for damage. It first destroys the bast layer of the tree, killing the latter, and then, by tunnelling into the heart-wood to pupate, it renders it useless for commercial purposes (*vide* Plate III).

Mr. Percival would appear to hold the opinion that the grub feeds on dead wood as well as living. I think the above description of the life history will show how this has come to appear to be the case. Both sawn timber and logs left in the forest with the bark on may contain larvæ but they will, in all cases, be nearly full-grown. The grub would be quite incapable of feeding in quite dry wood and even the pupa and beetle require that the timber should be still comparatively unseasoned, since seasoned timber will have so shrunk that the pupal chambers contract and kill the insects within them.

I agree with Mr. Percival that dying (not dead) standing trees are more liable to attack than healthy ones but in the case of severe infestations of the pest in a block of forest the beetles will attack healthy trees when either the stock of dying trees is giving out or they have themselves increased in such numbers that the supply of the material they prefer is running short.

VII.—Methods of Protection.

In the case of an insect of this kind there is but one way at present of combatting it successfully in India and that is the drastic one of cutting out seriously infested trees. These should be barked and if it is seen that they contain a large number of grubs the trees should be logged and burnt. It will not be necessary to reduce the whole to ashes, if there is no demand for charcoal in the locality. If the sap-wood is properly burnt sufficient heat and smoke will have penetrated into the interior of the heart-wood down the larval galleries to have killed off all pupating grubs, pupæ or nearly mature beetles. This operation may be done at any time of the year except when the beetles are issuing, *i.e.*, between the beginning of May and end of July.

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* Only in case of very severe attacks of this insect when the cambium layer of the tree is so full of the caterpillars that the small irregular-shaped galleries coalesce would this insect be able to kill the teak trees.

It must be remembered that infested trees in a block of forest mean the spreading of the pest to neighbouring healthy ones and that consequently the sacrifice of the infested patch will save the rest of the block. In carrying out the operation the greatest care should be exercised in seeing that the logs are properly burnt and that any large branches showing signs of the presence of the beetle are treated in the same way.

Range officers should be instructed to report the fact of there being dying trees or dying patches of trees in their charges and with the report they should be able to state whether the damage is due to the presence of this pest. If the trees are being killed it may, if the matter is taken in hand sufficiently early, be possible to save the timber from being ruined, since it has been shown that the insect takes two years to pass through its life cycle although the signs of the infestation will probably be visible in the tree during the insect's first year of life.

VIII.—Points in the life history requiring further observations.

The life history of this insect is almost complete saving in one or two particulars.

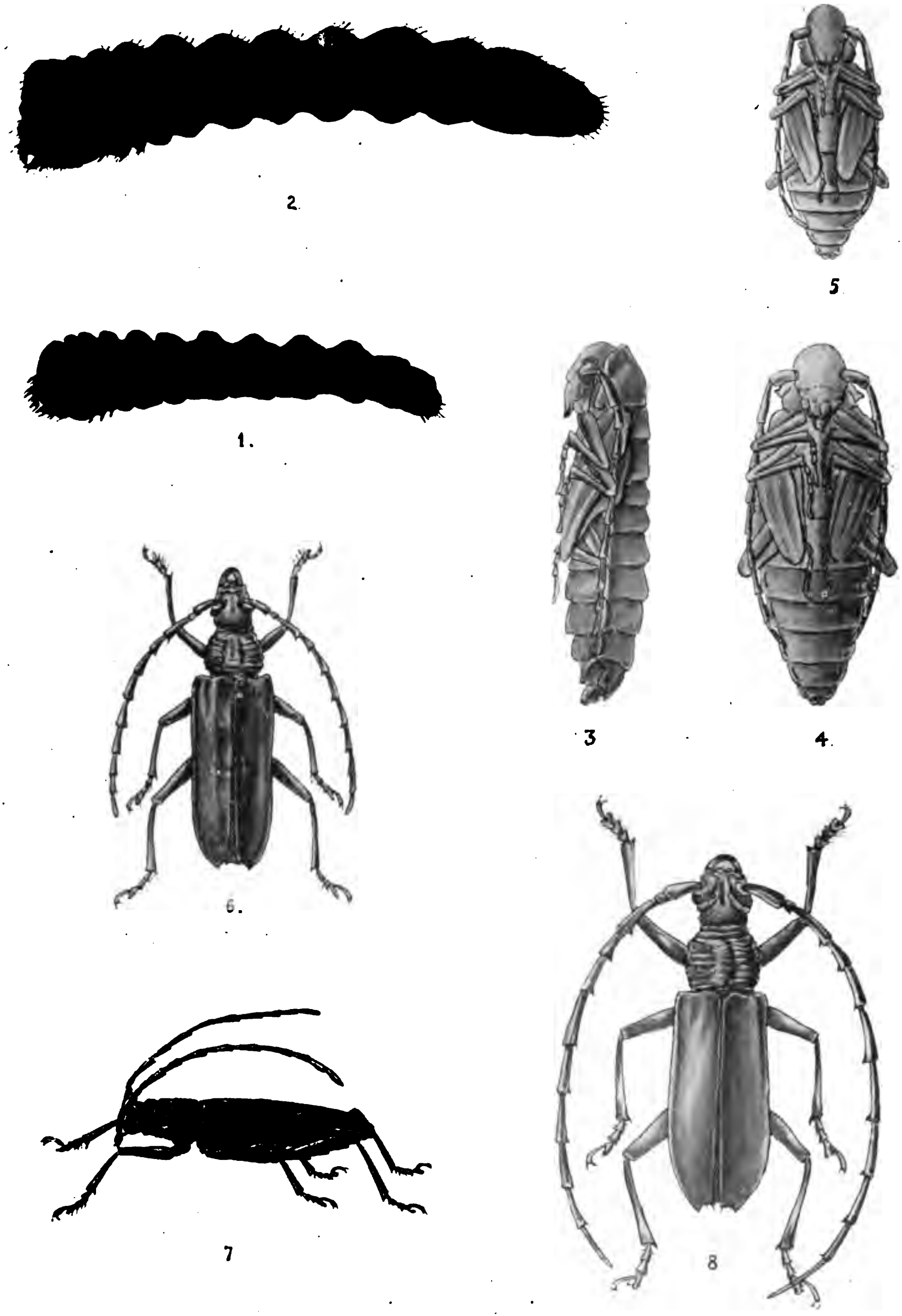
1. We still wish to know exactly where the eggs are laid, the number laid and whether they are all deposited at one spot or laid in clusters on the same or on different trees. It should be easily possible by procuring and keeping some male and female beetles in a box to ascertain the number of eggs laid. Before death the female will deposit her eggs on the sides of the box when she finds that the material she requires is not available. These eggs will probably not hatch but their number will be ascertainable in this manner.
2. The exact period of life of the larva. Is it, as appears probable, about a year and a half. By examining the size of the larvæ in the trees at different periods in the year this will be determinable.
3. The period spent by the beetle on the wing.

G. I. C. P. O.—No. 2 For. Zool.—30-7-1906.—750.—J. E. F.

PLATE I.

Fig. 1. Larva, two-thirds grown.
„ 2. Larva, fully grown.
„ 3. Pupa, ♀, side view.
„ 4. Pupa, ♀, ventral view.
„ 5. Pupa, ♀, ventral view.
„ 6. Beetle, ♀, dorsal view.
„ 7. Beetle, ♀, side view.
„ 8. Beetle, ♂, dorsal view.

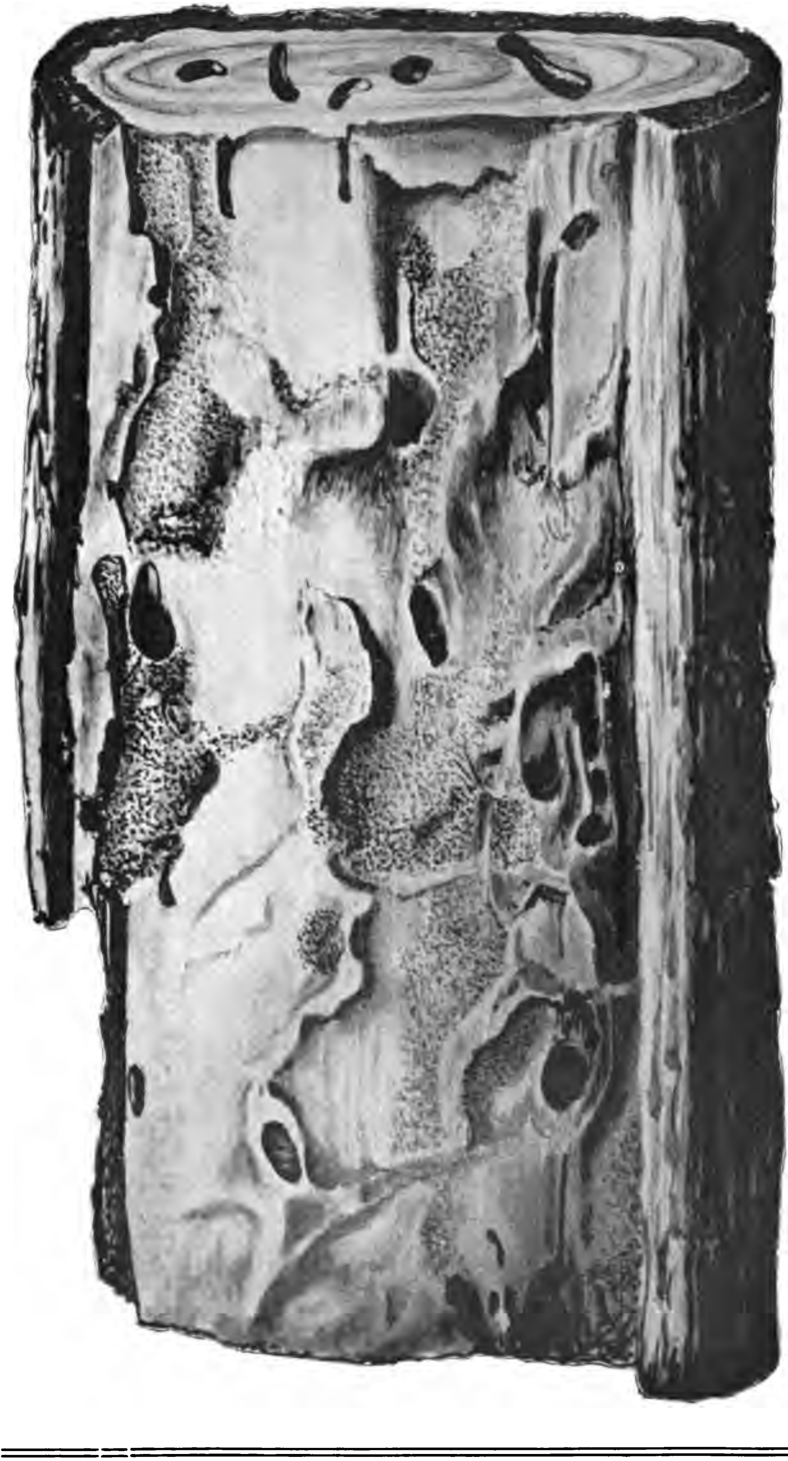
Note.—**All figures are natural size.**



Hoplocerambyx Spinicornis.
The Singhbhum Sal Borer.

PLATE II.

Section of a trunk of an infested Sal tree showing the larval galleries in the cambium layer and sap-wood. The destruction of the cambium thus caused results in the death of the tree.



Galleries made by the larvae in the bark and sap wood.

Photo.-Mechl Dept., Thomason College, Roorkee.

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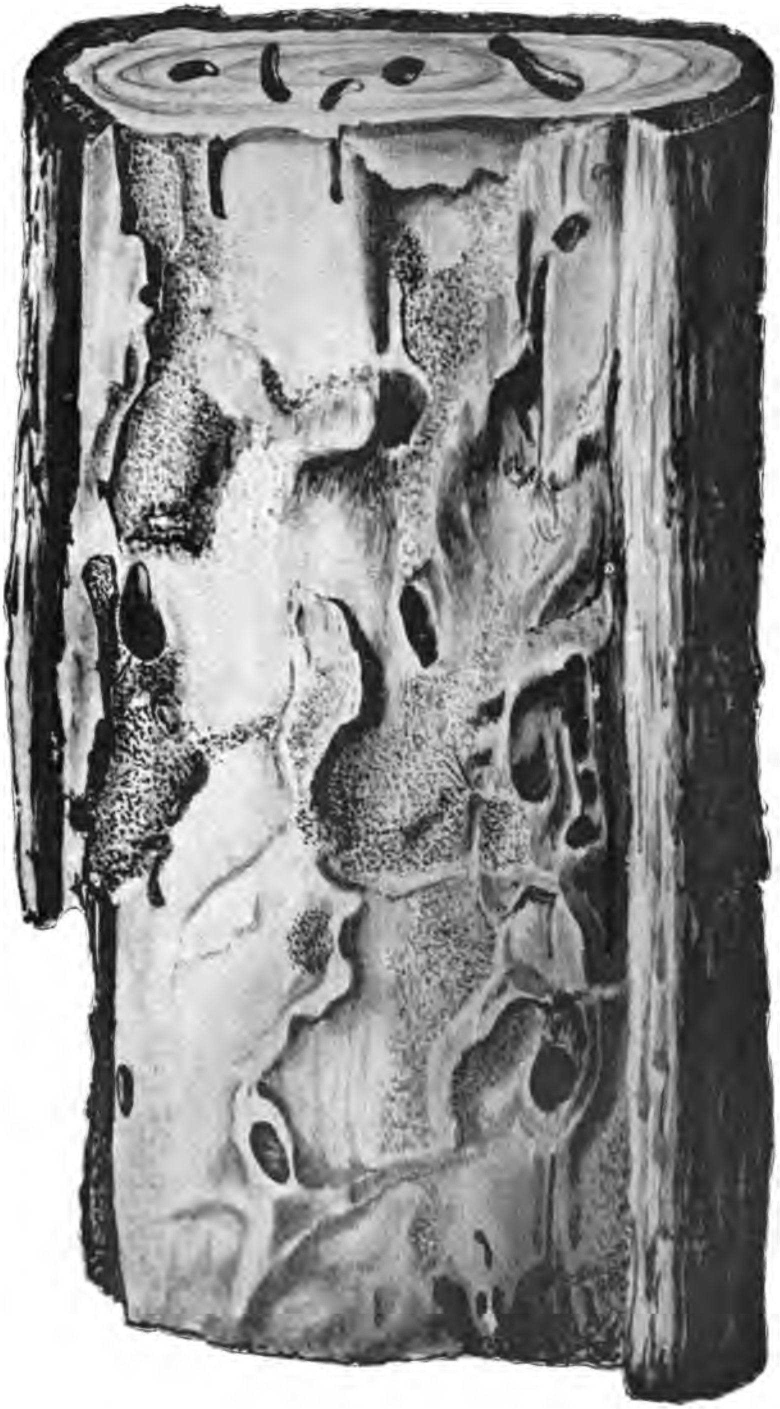
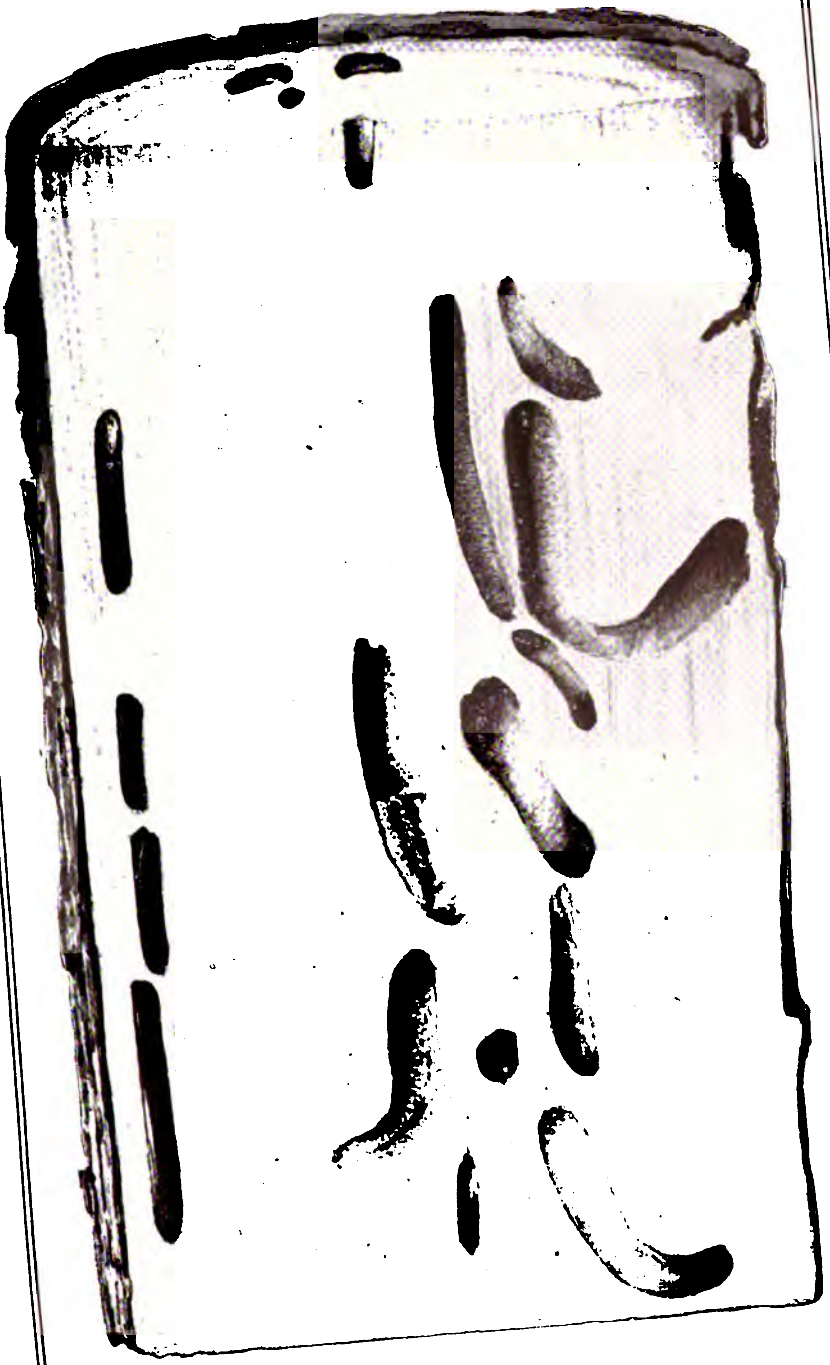


Galleries made by the larvae in the bark and sap wood.

Photo.-Mechl Dept., Thomason College, Roorkee.

PLATE III.

Section of the heart-wood of a Sal tree showing the pupal chambers entirely destroying the timber of the tree.



Pupal chambers in heart wood.

Photo.-Mechl. Dept., Thomason College, Roorkee.

Forest Bulletin No. 9. 1906.

NOTES

ON

THE INFLUENCE OF FORESTS

ON

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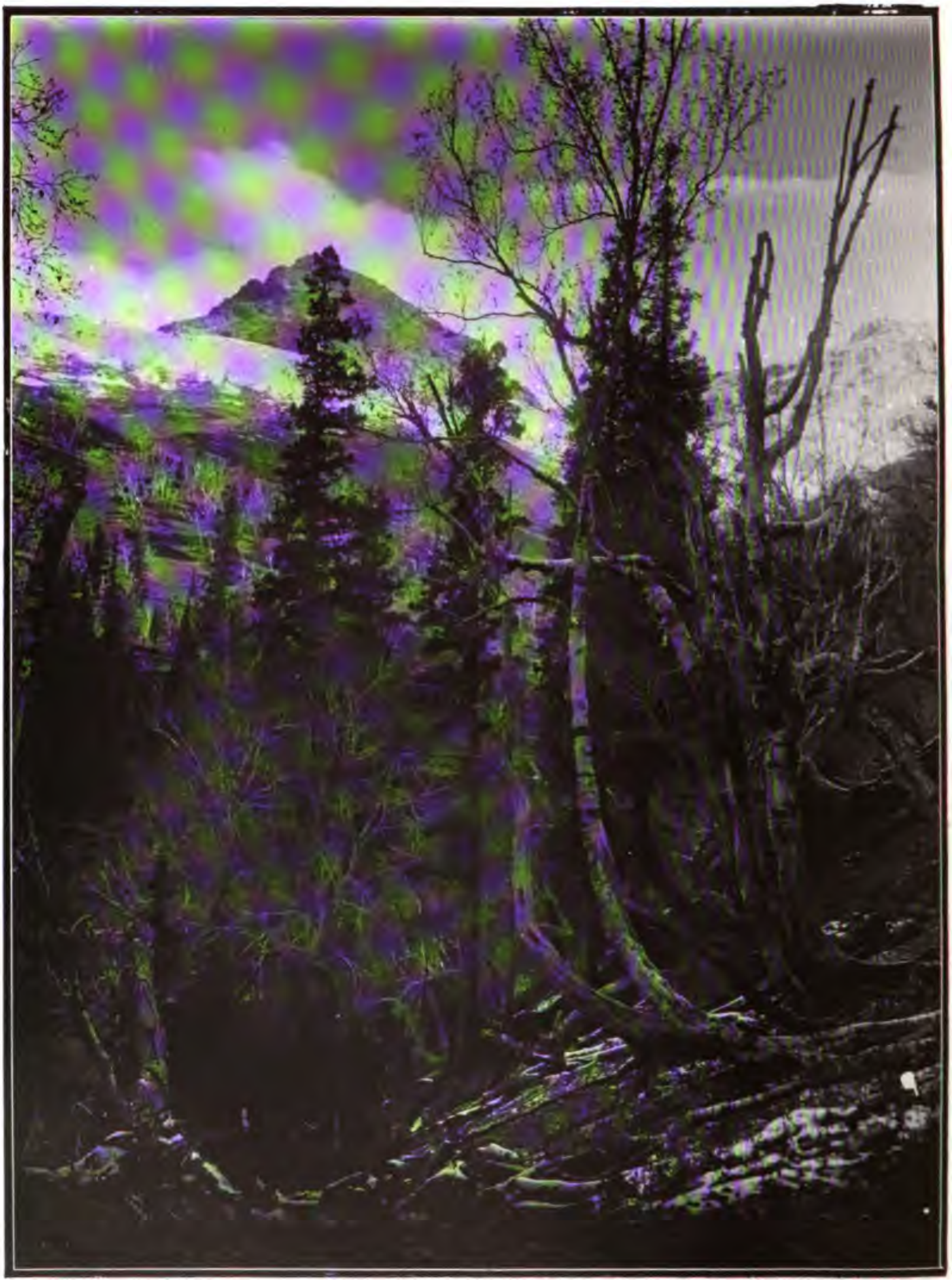
CALCUTTA:
GOVERNMENT OF INDIA CENTRAL PRINTING OFFICE,
8, HASTINGS STREET.

PLATE I.



Eardley-Wilmot.—Influence of Forests.

BIRCH FOREST IN KASHMIR.

Showing typical curvature from snow pressure and tree killed by lopping.

[Frontispiece.

Photo.-Mechl. Dept., Thomason College, Roorkee.

NOTES

ON

The Influence of Forests on the Storage and Regulation of the Water Supply.

"In nature there are no rewards or punishments; there are consequences."

Part I.

EUROPEAN RESEARCH INTO *FOREST* INFLUENCES.

Reasons for delay in enquiring into the influences exerted by forests.

THE question of the mechanical influences of forests on the water supply of India has, during the past few months, once more come into prominence. During the 40 years that have elapsed since the constitution of an Indian Forest Service the subject has not received the attention it deserved for the reason that it was at first a matter of paramount importance to create State Reserves and to define the State ownership of forest and waste lands which were rapidly being absorbed. The extension and consolidation of the Empire, the fostering of internal and external trade with its inevitable results in the improvement of communications by river road and railway, the increase in population and of agricultural operations, all these were factors which rendered it essentially necessary to secure for the supply of forest produce what forest and waste land was still available, to preserve it for the use of the State, and to so protect it that it should yield in timber and other produce the requirements of a population growing both in numbers and wealth.

The numerical strength of the Forest Department was naturally at first quite inadequate to cope successfully even with the direct economic questions which were then involved. Reservation and settlement progressed slowly, and the latter was subject in some provinces to repeated revision, while the opening out of the forest areas in order to profit financially by the creation of State Reserves occupied the attention of the forest staff perhaps somewhat to the exclusion of what are elsewhere recognized as equally or even more important aims. In those days, and not infrequently even at the present time, the reasons for refusal to reserve or for disforestation were given as "the land carries no valuable timber" or "the land is required for cultivation" without perhaps sufficient consideration either that forest growth for which there is no market demand is often of inestimable value in clothing hill slopes, or that cultivation, once successful, may become precarious or even impossible when its extension necessitates the annihilation of a protective forest growth.

Matters progressed on the lines above indicated for many years, the efforts of the Forest Department being directed solely to the acquisition of State Reserves and to their organization, there being barely time for adequate protection even from fires and grazing, while the compilation of Working-Plans in order to ensure a regulated scientific treatment could not keep pace in some provinces with the organization of the State Forests. In these circumstances it is not surprising that the Forest Officer earned the reputation of a remorseless land-grabber whose sole objects were to increase the area under departmental control and to collect the largest revenue as a justification of his action.

The first public statement of forest policy in India.

In 1894 appeared the first public expression of the forest policy of Government which laid down that "*the sole object with which the State Forests are administered is the public benefit.*" The forests of India were therein classified under four heads, the first of which comprised "*forests the preservation of which is essential on climatic or physical grounds,*" but it is explained that "*it is not intended that any attempt should be made to class existing State Forests under one or other of these four heads*" and that "*the classification is useful only as an indication of the broad policy which should govern the treatment of each class respectively.*" Proceeding it is said that with this class of forest "*the interests to be protected are important beyond all comparison with the interests it may be necessary to restrict and so long as there is reasonable hope of the restriction being effectual, the lesser interests must not be allowed to stand in the way.*" In regard to cultivation *versus* forests the rule is laid down that "*the claims of cultivation are stronger than those of forest preservation*" and that "*where an effective demand for culturable land exists and can only be supplied from forest areas the land should ordinarily be relinquished without hesitation.*" Certain conditions control the application of this principle such as "*where the physical conditions are such that the removal of the protection afforded by forest growth must result after a longer or shorter period in the sterilization or destruction of the soil,*" lesser interests must not be allowed to stand in the way; and "*cultivation must not be allowed to extend so as to encroach on the minimum area of forest which is needed to supply the general forest needs of the country or the reasonable forest requirements, present and prospective, of the neighbourhood in which it is situated.*" Finally "*in many tracts cultivation is practically impossible without the assistance of forests and it must not be allowed to destroy that upon which its existence depends.*"

The remainder of this long resolution is devoted to the forest crop and to the method of its disposal.

There is no intention of criticising this exposition of forest policy, which has been of great value in directing public attention to the economic value of the State Forests and in insistence on the necessity of utilising them for the more direct material advantage of the agriculturist. There can be no doubt that the operations of the Forest Department have since been viewed with more sympathy, which was the more readily afforded in that the preliminary operations for the creation of State Forests were approaching completion and future work was more in the direction of improvement, which affected but little the present convenience of the peasantry, rather than of acquisition, which outraged their firmly rooted ideas of proprietorship.

But in order to make these introductory remarks intelligible as a record of the sequence of past events it is necessary to point out that in the Resolution to which we are referring it was not intended to enter fully into the subject of the beneficial mechanical influences of the forest, and that these received but a passing reference inadequate to what is now known to be their importance, while no mention was made of the necessity of maintaining a permanent water supply but only of "*protection from the devastating action of hill torrents of the cultivated plains that lie below them;*" in short, that the point of view then selected was one involving almost entire absorption in the contemplation of the yield of the forest and its disposal, while the consideration of forestry in its more indirect connection with agriculture was postponed to some future period when its discussion would have become more urgent.

Necessity for further investigation.

It was, however, inevitable that, in a country whose welfare is dependent on agriculture, attention should sooner or later again be irresistibly attracted to the fuller utilization and more careful regulation of the water supply which either in excess or deficit has so often been the cause of widespread misery and loss. For the subject possesses no novelty even in India. In 1847 the Court of Directors caused enquiries to be made into the effects of destruction of the forests once growing on the catchment areas of important water-courses, but here, as also in other countries, the question was ultimately set aside in favour of those of greater local urgency. Thus we have little actual official record based on scientific observations of a diminution from period to period in the volume of our perennial streams and perhaps still less of changes in their seasonal flow, and so, while investigations of ancient documents show sometimes an almost incredible difference between the actuals of 60 or more years ago and those of the present day, we are apt to withhold beliefin statements put forward as facts although these are in agreement with the experiences suffered in other countries where older and more reliable records exist. Of such countries we propose to select France to supply facts and statistics bearing on the subject of these notes, first for the reason that this is the country where careful investigation and research have continued probably for the longest period and where their results have been the most recently made known; secondly because the problems which must in the near future be solved in India are those occupying at the present moment the careful attention of the Government and of the Forest staff in France, and lastly because the area threatened by the consequences of denudation is probably larger in France than in any other European country.

French Reports on the effects of denudation.

We have before us a report of Mr. de la Grye read before a Committee convened by the Minister for Public Instruction in March 1906 and which was unanimously adopted by the members present. The report refers to a collection of some 38 pamphlets published by M. Fabre, Inspecteur des Eaux et Forêts, in which the subject of the devastation caused by denudation and its causes are very carefully dealt with. The writer, who received the congratulations of the Committee on his work, describes the struggle that is always going on for and against water, on the one hand to assure the benefits it confers by natural storage for irrigation purposes in time of drought, and on the other to mitigate the damage it may equally well cause by unregulated flow. In this struggle nature is an ally and man an enemy, because the latter utilizes the forest by burning, by grazing and other mal-treatment in a manner contrary to his own ultimate interests. The aspirations of the revolting peasantry of a 1,000 years ago are set forth in an old quotation. " No man, said they, shall have lordship over us, we will cut the trees and take the game of the forest and the fish of the rivers, we will do as we desire in the woods, in the meadows and in the streams" and this claim to absolute individual freedom is still present in some degree in the modern French peasantry and is explanatory of the difficulty experienced in inducing them to submit to the interests of the community, and in eradicating the belief that they have the right to constitute themselves the originators of those disastrous floods which are so largely due to their want of self-restraint.

Evidently then it is not only in India that these difficulties are encountered, and even in America where the liberty of the individual is unquestioned the dangers of denudation are everywhere recognized. There forest fires are credited with the annual destruction of property to the value of some £2,400,000 and the forests that escape from the fires are devoured by the wood-pulp industry. In Canada the value of this industry has risen from £16,000 per annum to £240,000, and in Norway a proportionate increase is observed, so that Governments are forced to intervene in order to create State Reserves with a view to the direct and indirect welfare of the country.

Reverting from generalities to particulars M. Fabre draws attention to the floods which occur suddenly in the absence of local rains; he gives instances of one which rose some 13 feet in 10 minutes and of another which caused an almost instantaneous rise of about 22 feet, and he proves that on the Pyrenees the chief aqueous precipitations occur when the clouds touch these mountains between the elevations of about 300 and 5,500 feet. He calculates that in the case of the Gironde river the deposit of silt caused by violent floods, which also result in preventing its navigation, causes an annual loss of £120,000, while the proprietors of the soil in the valley of this river are losing annually some £80,000 indirectly from the same cause. Again, at this time, though enormous sums have been spent on the improvement of the port of Bordeaux, no effective result has been obtained; the river pours annually 225 million of cubic feet of soil into the sea and at the same time the bed of its stream is being continually raised by the deposit along its course of the heavier sand, so that now large vessels have been obliged to abandon Bordeaux as a port, though there is nothing to show that Pauillac, which they now visit, will not also soon become impossible.

The cause of all these disasters is explained after years of careful observation to be traceable to the unrestrained rush of the rain water from the mountains which results in the formation of deep ravines on the hill sides and in the removal of the fertile soil which formerly covered the denuded slopes. This denudation of the soil is shown to be due entirely to the action of man, to the forest fires which he permits, to excessive grazing, to the removal of leaves and other forest litter, and to other ill-treatment which benefits the individual at the expense not only of his successors but of those at a distance who are dependent on agriculture and also on other industries utilizing a regular flow of water. M. Fabre describes the struggle perpetually proceeding between nature and man, the former constantly endeavouring to clothe the soil, the latter as regularly uncovering it, and he concludes by remarking that the damage done to the trade and industries of France might be repaired by utilizing a small percentage of the money, which is now wasted in fighting the torrential deposits of soil and sand lower down the river courses, in afforestation of the catchment areas of its rivers.

Budget Debate of 1906, in the French House of Commons, with reference to denudation.

Let us turn now to the Budget debate in the French Chamber of Deputies in March 1906 during which no fewer than 12 Deputies addressed the Chamber on the urgent necessity of preservation and extension of forests in the mountains. The matter must be deemed of considerable national importance when so much time was freely given to it and when the Minister for Agriculture had so carefully to explain his position and was so repeatedly called on for detailed information. The debate opens with objections to the reduction of the budget grant for protecting and restoring mountain forests to a sum of £131,000 which is deemed quite insufficient, the total area threatened being only 900,000 acres, especially when in former years over £160,000 were annually spent for the same purpose in protective works and in the acquisition of land necessary to carry these out. The first speaker gives examples of whole villages threatened or swept away by the action of mountain torrents, of cases where the beds of these torrents are now higher than the village sites, and he, while complimenting the forest service on their work, makes an urgent appeal for more funds for the protection of forests, for the regulation of grazing, without which the security of the plains as well of the mountains and of a great source of national wealth are endangered.

Reference is again made to the silting up of navigable rivers; of the condition of the Gironde we need not again write, but of the Loire river it was asserted that during the last 60 years 360 million cubic feet of soil have been deposited between Nantes and the sea, or a larger amount than that excavated from the Suez Canal. If, depose the engineers, the high level valleys are left in their present state of denudation, the channel of the Loire will continue to diminish in breadth and depth and ultimately the harbour of St. Nazaire will become useless. It is the same with the Rhone river and with its valley, while the disastrous floods which occurred from time to time, in 1856, in 1887, in 1895, show that there is no time to be lost in regulating the flow of water from the hills.

It was, at the close of a very lengthy discussion, agreed to pass a resolution by which (i) the estimate for the preservation and creation of mountain forests was restored to £137,000 and (ii) a demand was made to Parliament to grant sufficient funds to push on old and undertake new works. This result was, however, not deemed satisfactory to some of the Deputies who were of opinion that the grant was still inadequate to the necessities of the case. It is pointed out that following in the floods of 1856 a sum of nearly £7,000,000 had to be expended in repairing the damage done to roads, drains and dykes and that to prevent future disasters more money must be rapidly spent in ensuring by the creation of forest growth that the rain water should flow gradually through the soil instead of boisterously from its surface. The expenditure on deepening river channels in order to facilitate navigation was by them held to be useless unless arrangements were also made that there should at all seasons be water in those channels.

The Minister for Agriculture declares himself in accord with the demands of the Deputies, but represents that he is hampered by the Minister for Finance. He points out that afforestation is not the sole remedy for the protection of mountain slopes, but that in pastoral countries the creation and careful preservation of grass growth is also necessary. He alludes to the hostility of the proprietors which, however, with careful treatment is diminishing, insists on great tact being required in order to carry out the operations and to the necessity of aiding communities to carry out protective measures which are conducive to their own interests. On the whole, however, the Chamber is not quite satisfied with the sympathy of the Minister and go so far as to hint that they prefer action to words. Especially they demand that clear felling on mountain slopes, whether in private or Government forests, should be controlled by the State, and to the reader it is apparent that their views are founded on solid facts, that their demands are made in the interests of the nation, and that as such they will sooner or later be conceded according as insistence is more or less intense.

To an English reader perhaps the most remarkable aspect of the report and debate above summarized is the complete unanimity with which all authorities concerned accept the necessity of forestry going hand in hand with agriculture, with industries utilizing water as power or in other ways, and with cheap transport of merchandize on the main rivers of the country. But this would not be remarkable to the natives of any other European country who are educated from childhood to acknowledge the necessity of forests and their beneficial influence. In no other country perhaps would the letter of Mr. W. G. Coldstream in a recent issue of the *Pioneer* be necessary, wherein the writer insists on the importance of so-called "Geoteretic Forest Conservancy" and suggests that as recruits for the Indian Civil Service are obliged to undergo a practical course of training in mensuration and survey, so also they should attend a course of lectures on "Geoteretic Forestry" at the Dehra Dun Forest College. It is certain that the almost general indifference or ignorance of forest matters of the revenue official of the past has been a serious obstacle to the practical advance of this Science, and though in the present day this is very far from being the case it is not impossible that an official exposition of the main principles of forestry would be a valuable addition to the education of those who are destined in the future to control the staple industry of India.

Facts regarding the influences of forests as proved by European observation.

We may now usefully proceed to consider in detail the reasons for the faith that exists in France and other countries in the physical influences of forests, and having this object in view, it is fortunate that at this time we are able to refer to a valuable work published in 1904 and entitled "Economie Forestiere" wherein the author, M. Huffel, who is an Inspecteur in the Forest Service and a Professor of the École National des Eaux et Forêts, has collected much up-to-date information, not only from France but from other countries, on the subject under consideration in this paper, and has added thereto his own experiences and conclusions in an extremely instructive and admirable manner. For in India practically no sustained research or investigation has been made into the subject of the mechanical influences of forests, the causes and effects of erosion have not been scientifically studied, and as we cannot wait for a long period of years to carry out original work we must be content to accept the proofs put forward by our colleagues in other countries and should be grateful for the knowledge they impart, recognizing that the results they have arrived at by patient study must be still more intensified in a country where rainfall, elevation and extremes of heat and cold are so much more marked. It is far from improbable that the effects of denudation in India are twice, thrice or even still more rapid than those which in France have been shown to have caused a diminution of the national wealth and which demand a large expenditure for their future prevention.

The following paragraphs will therefore be devoted to a summary of the physical influences of the forest as set forth by M. Huffel.

I. INFLUENCE ON AIR TEMPERATURE.

The effect of forests on the temperature of the air which surrounds them is of importance in that a low temperature encourages the precipitation of the moisture in the air. Distinguished scientists such as Humboldt held that forests reduced the temperature of the air by preventing the heating of the soil by the solar rays, by the vapour given off by the leaves, and by the nocturnal radiation from the large extent of the foliage; but it is only in comparatively recent years, from 1866, that careful observations were commenced in France, Germany, Austria, Switzerland and other countries in order to reduce surmise to certainty.

Thus it has been established that the *yearly mean temperature* is less inside than outside a forest. The difference is slight, averaging about 0·50° C. in the plains, but increases with the elevation so that it is about 1° C. at about 3,000 ft.

Further the *monthly mean temperature* is less in the forest for each month of the year, but the variation is much more marked in summer where it may amount to over 2° C. whereas in winter there may be only 0·1° C. difference.

Moreover, the *daily mean temperature* shows the same result but to a greater degree, so that the difference between the hottest and coldest days of the year registered inside and outside the forest may amount to over 3° C. and to over 1° C., respectively, giving a total difference of some 5° C.

The influence of the forests upon the temperature at different hours of the day is of importance, for by it the temperature is raised at the coldest portion of the day and so unseasonable frosts in early summer and autumn are less frequent and less destructive inside than outside the forest. The general results arrived at by these observations is that the forest climate is more equable though slightly colder than that of the open, but they do not prove that forests modify as a whole the climate of those regions in which they cover large areas. This point has, however, been the subject of further observation. An endeavour has been made to study the variations of the mean temperature of the month of July along one parallel of latitude, eliminating the influences of elevation, with the result that in richly wooded countries a decrease in normal temperature which may amount to 4·5° C. has been detected, while elsewhere meteorological statistics have shown that in well afforested regions there exists a decidedly lower temperature than in others, similarly situated, but denuded of the tree vegetation.

II. INFLUENCE ON SOIL TEMPERATURE.

The next subject with which we are concerned is the influence of the forest on the temperature of the soil—a matter of importance as a high temperature denotes more rapid evaporation. As the earth is heated and cooled at a much slower rate than the air it follows that its variations in temperature are also slower. It has been proved that a forest soil is warmer by about 1° C. in winter and cooler by 3° to 5° C. in summer and therefore that the variations of temperature in that portion of the soil into which vegetable roots penetrate are less by 4° to 6° C. in the forest than in open cultivation. The hotter the aspect the more marked the influence of forest growth in reducing soil temperature; thus on southerly slopes the cooling action of forest vegetation will have a more marked effect in retarding evaporation from the soil than on northern slopes which are sheltered from the sun.

III. INFLUENCE ON THE HUMIDITY OF THE AIR.

The *relative humidity* of the air is higher in the forest than in the plains, not because forest air contains more vapour, but because its temperature being lower, it is, when holding an equal amount of water, nearer its saturation point. The difference in favour of forest air, expressed in the mean percentage of saturation, varies between 9 and 12 per cent. and is highest in summer; hence the reason for the feeling of coolness experienced on entering a forest at this season of the year.

On the other hand the *absolute humidity* of air inside and outside the forest does not vary appreciably.

IV. INFLUENCE ON ATMOSPHERIC PRECIPITATIONS.

(*a*) Rain.

If it is true that air in the neighbourhood of large forests, especially in summer, is cooler than air outside the forest, it is natural to think that the rainfall in the forest would be in excess of that outside, because rainfall is due to the condensation of a part of the atmospheric moisture, and this condensation is generally due to a fall in temperature. The result of observations is to confirm the inference that the lower temperature of the air in the neighbourhood of forests induces an increase in the rainfall.

The stations inside, on the edge of, and outside the forest which have yielded a proof of this assertion are situated at Nancy, and have been in working order since 1866. Regular observations taken for 33 years show that without exception more rain has fallen inside than outside the forest, and that in 8 out of 10 times more rain fell on the edge of the forest than outside. Thus taking the rainfall at the centre of the forest as 100, then 93.9 represents the fall at the edge of and 76·7 the rainfall outside the forest. Further it has been ascertained that the above proportions are independent of the wind direction and that there is no appreciable difference in the influence of the forest on the rainfall in summer or winter—results which have been confirmed by other independent observations.[*]

Other observations undertaken in other countries serve to show that the rainfall increases with the extension of the forest area and thus, speaking generally, and not for one locality, it appears certain that, other conditions being equal, it rains more at the centre of a forest tract than at its edges, more at the edges than at some distance therefrom, and that the variation in rainfall is independent of the seasons and of wind direction, but is generally slightly more marked in wet than in dry years.

(*b*) Hail.

The result of observations tend to show that as a rule hail-storms cease when they encounter a forest well stocked with mature trees. Often it has been seen that such storms divide and pass on each side of such a forest, though immature tree growth has not the power to stop hail-storms in the mountains unless a mature forest extends in continuation thereof. The question, however, is not yet finally settled and is merely mentioned here in view of the great damage which in India is often caused to valuable cultivation by hail.

V. INFLUENCE ON SPRINGS.

In order to understand this difficult subject it is first necessary to define what is meant by a spring and also to ascertain what is the origin of springs. The definition of the word spring may be accepted as a " jet of water which forms a stream from the place whence it issues from the earth." It is admitted that springs are created by the percolation through the soil of atmospheric aqueous precipitations and it is calculated that the total flow of the world's water-courses amounts to only $\frac{3}{7}$ths of the water which falls within their catchment areas; there is, therefore, no need to seek further for any other source of supply. The water in penetrating the soil becomes less and less liable to evaporation and, having passed the limit occupied by the root systems of the surface vegetation, sooner or later forms subterranean sheets which find an outlet so soon as any depression of the surface soil reaches their level.

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[*] Similar observations made in other European countries offered similar proofs but in a less degree than at Nancy.

The level of these subterranean sheets of water varies with the abundance or absence of rain. The force of evaporation does not permit of them being situated near the surface and moreover the natural drainage encouraged by the roots of trees which penetrate forcibly into the soil, as well as the rising of moisture in the vegetation, is equally prohibitive of large accumulations of surface moisture. Other conditions being equal the "spring level" (which is that collection of underground water moisture which is relied upon to more or less permanently feed the wells) will be lower (*a*) if the soil is permeable to a very great depth; (*b*) if the rains are deficient; (*c*) if evaporation is more pronounced, and (*d*) if the depth of the soil subjected to drainage by the surface vegetation is excessive.

Three types of springs may be distinguished, those in permeable soils, those in stratified soils, and those in fissured rocks. In the first case, as the "spring level" varies with the configuration of the ground, such springs are rarely perennial. In the second, the water after passing the permeable soil is arrested on strata which are nearly or quite impermeable and the springs appear at the junction of these two types of soil, as in a valley which cuts their line of junction, in a ravine, or in some geological "fault." Thus there may be several lines of springs on one slope if only the strata are in different localities more or less permeable. In the third case, the water is concentrated in clefts and pockets and flows along those channels which permit of the movement of water. Thus such springs have often lengthy subterranean courses and carry off the rain from large areas, passing from reservoir to reservoir within the rock. Such springs are also remarkably full and constant, but they do not come under the definition first given because really they are merely the outlets of underground lakes.

In the olden times no doubt was entertained that forests directly favoured the feeding of springs in their immediate neighbourhood, but to-day some doubts are felt in this regard. We know that afforestation reduces or removes stagnant surface moisture, but whether this moisture is given off in the air by the action of the leaves or sinks into the soil assisted by the increased porosity caused by the growth of the roots, it is not so easy to affirm. It must be remembered that the water which feeds a spring may enter the soil at a very great distance from where the spring appears. To prove that forests directly and permanently affect the volume of springs in their neighbourhood the results of afforestation or denudation over a very large area must be observed and the effects on the springs within that area noted. So far it has not been possible to make this final test, and, as laboratory experiments cannot be taken as deciding the point, further detailed observations must be awaited before a definite conclusion can be arrived at. But another fact has been proved and is given as influencing the decision of the question under consideration, namely, that forest soil receives more atmospheric moisture (amounting in winter to 20 or 25 per cent.) than arable land, the reason for this being that trees condense from the atmosphere, specially in winter, a very large amount of moisture which flows in a liquid state to the earth and more than compensates for any loss in evaporation from the crown of the trees. Thus though there may be no springs in the immediate neighbourhood of the forest, yet forests increase the supply of moisture percolating through the soil and, therefore, it may be asserted, also increase the supply of underground water which goes to feed the springs appearing at a greater or less distance.

vi. INFLUENCE ON THE PERCOLATION OF WATER IN THE SOIL.

(*a*) General.

This is the most important influence exercised by forest vegetation. We have seen that more water falls on a forest soil than elsewhere and it is necessary now to investigate how the forest acts on the percolation of this water which is on its way to reach the so-called "spring level" of which springs are ordinarily the outlet.

Of the water which reaches the soil a portion flows directly over the surface and reaches the nearest water-course without absorption. Another portion is returned to the atmosphere by *physical evaporation*. A third portion after penetrating the soil is drawn up through the roots into the stems of the plants, and of this a part is utilized in the formation of vegetable tissue, the larger percentage being returned to the atmosphere through the foliage after having carried so far the mineral elements necessary for the growth of the plant. This phenomenon we distinguish as *physiological evaporation* and by it large quantities of water are removed from the soil at greater or lesser depths according to whether the vegetation on the surface consists of plants with a superficial root system such as grasses or with a deep-rooted system such as possessed by forest trees. A fourth portion of the water precipitated on the earth succeeds in passing the limit reached by the roots of the surface vegetation and sinks deeper into the soil until it encounters an impermeable stratum where it forms the "water-table" from which it may be drawn for utilization by means of wells, and the upper surface of which is generally spoken of as the "spring level."

Before proceeding further with this subject it will be here convenient to define the essential differences between springs in the mountains and in the plains. In the mountains the flow of rain water from the surface of the soil is of paramount importance, for the loss due to this cause is much larger than the sum of the loss from all other causes. Springs are much more abundant, numerous and useful in the mountains than in the plains; in the latter indeed the springs are either fed from water which has percolated through the mountain slopes, or their output is so comparatively insignificant as to have little direct effect on the water supply of the country. Further, in the plains the rainfall is, as compared with that in the hills, relatively small, so that little water is available to feed springs; in fact in the plains of Europe the soil often carries crops which absorb in their growth more than the annual rainfall, the excess having to be provided by irrigation. Finally in the plains the flowing off of surface water generally causes no serious permanent damage and the height of the "spring level" is chiefly dependent on the amount of evaporation and on the permeability of the soil.

(*b*) In the Mountains.

The percentage of the rainfall which flows from the surface of the soil depends on the angle of the slope and on the quantity of the rainfall or the rapidity with which the snow melts. It frequently amounts to 40 per cent., even to 50 per cent. on denuded slopes, and has been known to reach 75 per cent. on the occasion of a heavy storm over a limited area. The action of the forests on the flow of surface waters is so universally admitted that it serves no useful purpose to insist on it here. Briefly, (*a*) the foliage and branches of the trees break the force of the rainfall so that the water reaches the soil without violence, (*b*) falls of rain are more frequent and less violent in forests than in the open, while the melting of the snows is more gradual, being protracted for three weeks or even longer as compared with snow in the open, (*c*) the free flow of surface water is prevented by the obstacles opposed by roots, by fallen twigs and by absorption by mosses, dead leaves, and other surface covering of the soil. It is calculated that in Europe more than 2″ of rain water can be absorbed by the surface litter of a forest during 24 hours and it has been observed that even when this litter is saturated further aqueous deposits are only given off very slowly. In fact it may be stated that the flow of surface water *is completely arrested on forest slopes if these are clothed with healthy growth, so long as the leaf canopy is maintained.*

" Wooded hills attract the rain ; there it is that atmospheric precipitations attain their maximum, and there also are situated the important reservoirs and almost all the valuable springs. The mountain forests, particularly those at right angles to moist winds, induce the precipitation of most of the moisture these contain, while denuded slopes have little influence in this respect. For examples, take the hills which border the Adriatic and part of the Mediterranean which are noted for their aridity. Denuded of forests these hills are incapable of cooling the air and therefore of compelling the deposition of the moisture it contains."—(Professor Henry in the International Congress of Sylviculture at Paris.)

Thus it is certain that mountain forests exercise a most favourable influence on the absorption of the rainfall by the soil, and it is still more certain that when such forests are growing in a hot climate where physical evaporation is excessive their influence is all the more beneficial.

(*c*) In the Plains.

It has been before stated that the flow of surface water is comparatively inappreciable in the plains where the depth of the spring level is dependent on the absence or restriction of physical evaporation and on the permeability of the soil. Do forests affect this permeability? There is no doubt but that they do so by their root systems which mechanically separate the soil and permit the percolation of water, along the live roots which, on account of the swaying of the tree, are never very firmly surrounded by earth, and more so along the channels left by the decaying roots of dead trees. Moreover, it has been shown that the forest soil is warmer in winter than that in the open country, so that frosts are often prevented inside a forest, thus permitting of percolation continuing whilst outside the soil may be frozen so hard as to render infiltration impossible.

Physical evaporation is moreover less in a forest than outside it. Under a double screen of foliage and of dead leaves and other debris, evaporation proceeds with difficulty, and this effect is intensified by reason of the lower temperature existing under forest vegetation and by protection from the winds which blow freely over the open country.

vii. INFLUENCE ON THE AMOUNT OF WATER WITHDRAWN FROM THE SOIL.

We have no exact data regarding the quantity of water withdrawn from the soil by forests or field crops. In the latter the amount is in Europe often greater than the atmospheric precipitations during their growth, in the former owing to physiological evaporation the soil is drier within the zone tapped by the roots than within a zone of corresponding depth beneath agricultural crops. The opinion has ultimately been arrived at, but without absolutely definite proof, that forest vegetation does not lower the "spring level" immediately under it to any appreciable extent.*

We may now proceed to consider forests as a source of protection to man and to the works which are necessary for his livelihood or comfort.

viii. INFLUENCE ON THE REGULATION OF TORRENTS.

It has already been pointed out that the rainfall may flow from the surface of the soil to the nearest water channel to the amount of even 75 per cent. of its total volume. Such a flow may, if the rainfall be heavy, the slope steep, and the soil loose, carry with it solid matter, thus adding to its momentum, so that ultimately it becomes a torrent carrying rocks and boulders and capable of scouring deep channels in the earth. As the slope diminishes in gradient the force of the torrent gradually diminishes, the solid matter is deposited and the water flows away and gradually subsides. The typical torrent thus consists of an area scarred by the action of the water, a canal cut out of the soil or rock, and lastly of a fan shaped heap of debris. Such torrents are mostly dry but are in times of rain flooded with terrifying rapidity causing increasing damage as their catchment areas suffer from increasing denudation. Fortunately the area subject to torrential devastation is in Europe comparatively small, it amounts, for example in France, to about 887,000 acres, but within this area yearly some portion of arable land is removed so that the inhabitants assert that in the last 30 years more fields have been swept away than in the course of the last two centuries. The evil is therefore increasing, and the cause is the removal of forest growth and the abuse of grazing. In the olden days the utilization of forests and grazing grounds was minutely regulated, not only in communal lands but also in private properties; timber and firewood were removed only in accordance with fixed rules, the grazing grounds were closed for a portion of the year and the introduction of sheep and goats carefully supervised. But after the Revolution the communes became proprietors of the woods and pasturage and from this time dates their degradation; unregulated fellings, fires and excessive grazing soon altered the aspect of the wooded country and torrents commenced to form, often in a few hours, and to spread destruction in their course.

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* Recent investigations in sandy soils in France tend to prove that where the normal spring level is at about 6 feet from the surface the growth of maritime pine increases this depth, a fact which is not astonishing but would be probably of no significance save in absolutely similar circumstances. The fact that a matted layer of undecomposed humus prevents the absorption of water has also been proved.

In these circumstances it is not surprising that the following four propositions are accepted throughout Europe:—(*a*) That the presence of forest growth hinders the formation of torrents; (*b*) that the removal of forest growth facilitates the formation of torrents; (*c*) that the extension of forests causes the extinction of existing torrents; and (*d*) that the removal of forests redoubles the violence of existing torrents and causes others to appear.

Nature, it is affirmed, in placing the forests upon the hills, provides the remedy as well as the danger; for the forests fight the active forces of water with the living forces of vegetation. On the presence of the mountain forests depends the existence of cultivation and the life of the people, and if they are not maintained neither will the country below them continue to exist.

Of the manner in which the work of extinction of torrents, in France entrusted to the Forest Department, has been carried out it is not necessary to write in this note, nor is it necessary to discuss the influence of forests on sudden inundations, for these are generally directly dependent on the action of torrents to which liberal space has already been given.

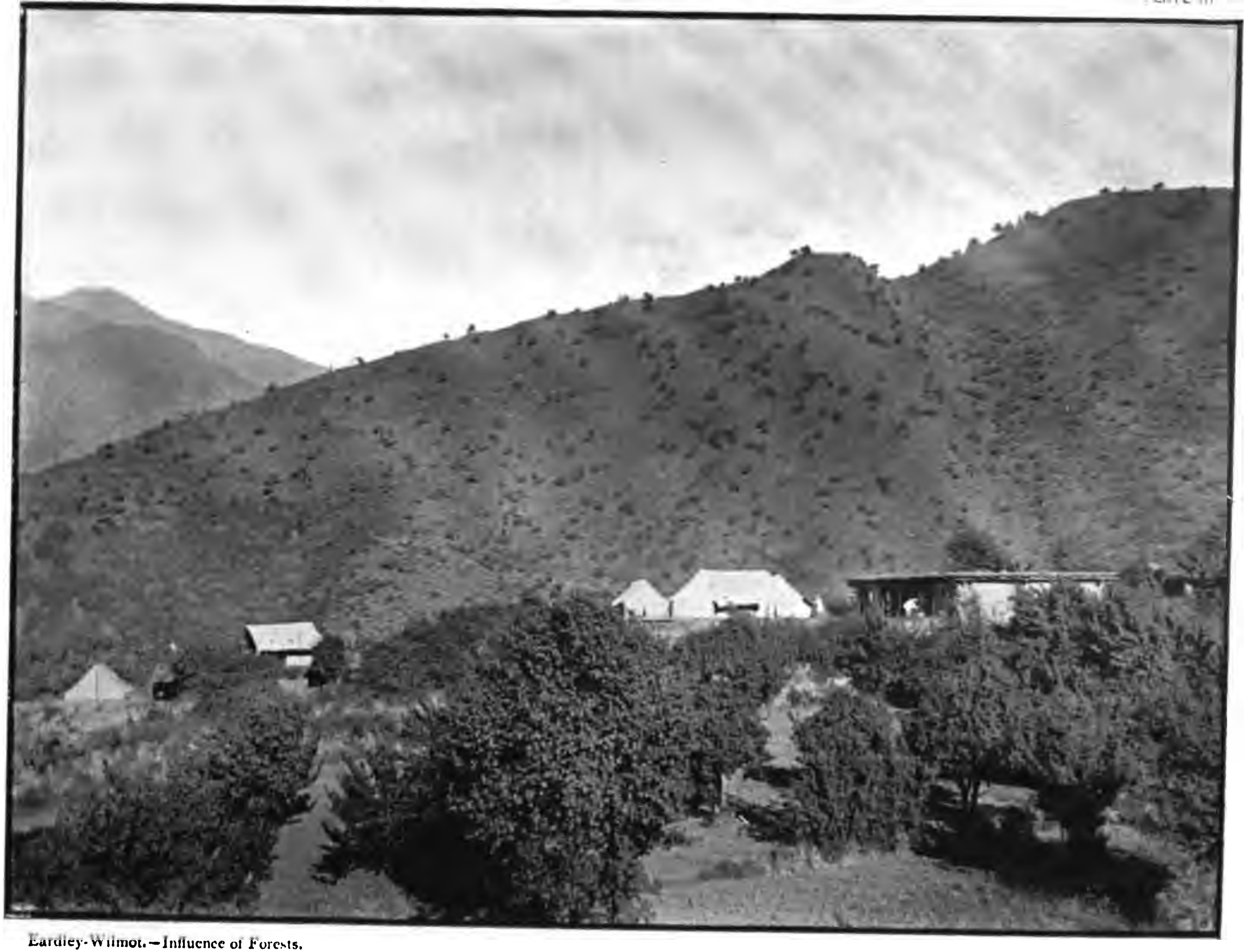
IX. INFLUENCE ON AVALANCHES.

Avalanches commence as a rule above the forest line or start from those areas which have been made into grazing grounds by man. Where forest growth is standing or where it can be again induced to grow, danger from avalanches ceases to exist. The damage caused by avalanches consists in causing denudation down to the bare rock, necessitating costly works of protection, and the sudden collection of large volumes of snow at a low level which may dam up water-courses and by rapid melting increase the violence of the floods which follow when the temporary barrier gives way.

X. INFLUENCE ON MOVING SANDS.

When the surface soil is composed of loose sand, the action of the wind produces the same effect as it does on water except that when the wind ceases the waves of sand remain stationary. If the area covered with sand is on the sea-shore, the sand is driven inland and its place taken gradually by the sea; if inland the sand may be driven over valuable arable land leaving behind it bare rocks and stones. The sole method of fixing moving sand is by afforesting the area, an undertaking which must be gradually carried out. In the first instance slight mechanical obstacles to the movement of the sand must be erected, such as hurdles and palisades, and in their shelter such vegetation as can exist must be sown or planted. Following on this procedure the sowing or planting of light demanding forest trees must be attempted. In this manner the seaside "dunes" of France have been covered with valuable forests of maritime pine which now yield a large revenue in timber and resin, while in many other European countries desert areas which were threatening to encroach on the adjacent cultivation have been afforested.

There are other forest influences which it is not proposed to discuss in this paper such as the advantages of afforestation of waste land unsuitable for cultivation, the hygienic importance of forests and their æsthetic value. Enough has already been written to set forth the main facts—the result of many years' careful scientific investigation—which regulate the intimate connection between forests and the water supply, facts which are acknowledged as such throughout the civilized world, which are common knowledge to the French Member of Parliament and are accepted by his Government as a basis of discussion in the Chamber of Deputies. It remains to endeavour to apply to Indian conditions the knowledge which continental forest officers and other scientists have placed at our disposal.



Eardley-Wilmot.—Influence of Forests.

DENUDATION IN THE CHENAB CATCHMENT BASIN.

Showing destruction and prevention of Forest growth

PART II.

APPLICATION OF RESULTS OF EUROPEAN RESEARCH TO INDIAN CONDITIONS.

THE mechanical effects of forest vegetation on the storage and flow of water should vary in degree with the intensity of the climatic influences they are designed to modify. In other words the benefits conferred by forest growth should increase in value where rainfall is in excess or deficit, where the seasonal temperatures are high, and where the gradients of the hill sides are steep, so that tropical or sub-tropical countries would appear to present the very conditions where the preservation of forests in suitable localities may become a matter of vital importance. India furnishes an excellent example of this, the chief industry being agriculture which is dependent entirely on a timely water supply, provided either direct from the atmosphere or by rivers, tanks or wells. We know to our cost that in many places in the present condition of the country no certain dependence can be placed on seasonable rainfall, and we may yet learn that, if any considerable portion of the aqueous atmospheric deposits is permitted to run to waste, India may later on, as other countries have, find her rivers, and therefore her canals, with an even more irregular flow of water than at present, and a subsoil to which insufficient moisture has filtered to supply the wells at a reasonable depth. It has been shown that properly located forests tend effectively to diminish this waste, and, especially in the hills, permit the formation of natural reservoirs from which a perennial flow proceeds, and it is therefore rather more than probable that in India the indirect value of forest growth may be of far greater moment than the direct benefits it at present confers, valuable as these may be.

In India the denudation of the hills and catchment areas of the rivers certainly affects larger interests than those of the individual or local community; these indeed may lose houses and land in consequence of the unrestrained action of heavy rainfall, but the State as a whole suffers when famine is frequent over large areas and when torrents are unloosed causing a waste of water, which should be stored in the soil for use during the dry season, and carrying devastation may be hundreds of miles away to towns and cities and to expensive public works designed to secure immunity from famine or to facilitate the commerce of the country. The distribution of the water supply by means of canals, of dams, of tanks and wells is within the power of man, and this important work would be comparatively easy if our rivers and streams and springs flowed permanently and equably; it is a different matter when their courses are alternately dry and in flood, because nature's efficient system of storage is ignored, and because dependence is placed more or less entirely on the surface flow of water which the forests appear specially created to prevent. Even if the continued efficiency of the distribution works constructed at so large a cost were alone considered it would appear reasonable to insist on such measures being taken as would ensure that in the future a regular and more even supply of water should reach these works wherever this was possible.

Indian rivers.

The rivers of India may be divided into two classes, first those fed primarily from the glaciers of the Himalayan or trans-Himalayan tracts, and secondly those with smaller catchment areas which are more entirely dependent for their flow on atmospheric precipitations. In the former category come all the great rivers of Northern India, in the latter the smaller rivers of that area as well as all the other rivers in the Peninsula.

It might at first sight be concluded that the flow of the glacier born rivers of India was beyond the control of man, but further consideration will show that while the melting of the snow and ice in summer and glacial pressure in winter combine to secure a perennial flow of water, atmospheric precipitations are responsible to a still greater degree for the variations in flood level which are accepted as characteristic of these great rivers, and that these precipitations are most marked in the hill ranges which must be passed before they debouch into the plains. The reasons for this have already been indicated, namely that forest clad hills compel, by the obstacle they oppose to the monsoon currents and by their lower temperature, the deposit of water from moisture laden winds, and in India this phenomenon is so far marked that many instances are known where the rainfall at the foot of a mountain is many times less than on its slopes though these may be only a few miles distant.

A correspondent from Kashmir writes in August 1906 to the *Pioneer* as follows:—

> "The long predicted floods have not yet come. In fact the Jhelum is abnormally low in spite of the vast masses of snow still lying on the hills and the fierce sun. The truth is that the Jhelum never rises to flood level from the melting of the snows alone, it must be combined with at least three days of constant rain."

This then is further evidence that the normal flow of water from the glaciers is uncontrollable, but at least so constant as not to give rise to any injurious results, and it becomes evident that the catchment area between the snows and the plains is that portion of the river's course which should receive the most careful attention as being the area within which the forests are capable of preventing avalanches and torrents and of storing up a large proportion of the monsoon waters to give them off gradually in perennial springs and streams.

The course of these rivers from their origin some little distance below the permanent snow line to that point where they reach those important works designed for the distribution of their waters for irrigation purposes is of interest. But first it may be remarked that below this point there can at the present day be little control over these large streams and that so long as floods from their head waters are efficiently controlled there would probably be but occasional damage from inundations in a level country due to local rainfall, whilst frequently such inundations, though causing temporary loss, are of considerable benefit to the agriculture of a province.

From the glaciers of their origin then to the upper limit of tree vegetation nothing can be done and little is needed to control the course of the Himalayan rivers, but from this point onward the influence of atmospheric precipitations is felt, at first but slightly but increasing with decreasing elevation.* Here, too, is first found the stiff shrubby growth of dwarf rhododendron and juniper effective in protecting the surface soil, and close below the birch forests whose curved stems bear witness to the resistance they afford to the pressure of masses of snow from which they will not be free till late summer. Below these again come the firs, pines and cedars, forming naturally dense forests, and succeeded by the oak and pines of lower elevations merging gradually into the broad leaved species which clothe the lower slopes leading into the level country. Such is the protective belt which gives security to the people of the hills and assures prosperity to those in the plains, and nature if left to herself is powerful enough to maintain the protection she has afforded. Man, however, will have none of it; commencing from above he lops the birch forest for his goats or kills it for its bark, the coniferous forest he destroys by fire or prevents its regeneration by excessive grazing, while at lower elevations by unregulated fellings, by lopping and by grazing and burning he speedily denudes the hills and lays them open to the disintegrating effects of wind, sun and water, and in such circumstances it is not surprising that sudden and disastrous floods should work havoc in the lower reaches of the river.

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* Broadly stated the rainfall is heaviest in India from the foot of the hills up to about 7,000 ft. elevation, decreasing gradually until the permanent snow level is reached.

With regard to those rivers which rise at lower elevations in the plains it has before been pointed out that protection from excessive evaporation and suitable porosity of the soil are the main conditions which permit of the adequate storage of water and that forest growth encourages these conditions. Thus the rivers of the plains demand, in order that a perennial flow shall be assured, that their catchment areas should be protected so that the local rainfall on which the water supply is dependent shall not run off in flood but be stored in the soil for future use. This is also of importance where irrigation depends on wells whose depth again is dependent on the percolation of rain or river water, or on dams erected to raise the level of water in a river for the purposes of distribution. For where a full supply of underground moisture is available in the catchment area of a river and along its course the flow of water may remain fairly constant in spite of evaporation and utilization, owing to the tapping of successive water tables at varying levels, while in no case would alternate floods and droughts be probable.

On this subject Mr. Frankenfield, Professor of Meteorology, Weather Bureau, U. S. A., writes:—

> "During the low-water seasons of the late summer and the autumn it is sometimes observed that after a time the rivers reach a level which, without any material increase in the amount of rainfall, is maintained for a considerable time. At other times the waters continue to fall even though the rainfall is more abundant than is usual for the season. It will usually be found that these phenomena have intimate connection with the variation in the level of the underground waters. If the supply of ground water has been near or above the normal level, the streams will continue at normal low water stages. If, on the other hand, the supply of ground water

as indicated by its height in wells, etc., has steadily decreased during the previous year or more, then the surface streams may be expected to fall below their usual low water levels, notwithstanding the fact that an average amount of rain has fallen. If the ground water level has been falling for several years on account of deficient rainfall, the surface streams will probably continue to fall, even though the rainfall be appreciably more than the average. The ground water must first find its normal level, before the full effect of the rainfall can be felt. The effect of forest covering upon stream flow is indeed a vital subject, and a thorough acquaintance with it is absolutely essential if further real progress is to be made in the study of river variations. It is true that it is but one factor of many, but none is so important, both in a negative or positive sense."

With regard to tank irrigation that which is dependent on the flow of water from the hills is also dependent on the forest growth for its permanency, while with reference to tanks supplied direct by local rainfall nothing need be said, for here man unaided proposes to store and distribute the water supply, and the economy and efficiency of this method is open to grave doubts.

To recapitulate the arguments concisely :—

(i) Speaking generally the water supply of India is probably more than sufficient for the requirements, agricultural and industrial, of the country if not allowed to run to waste.

(ii) The storage and regulation of this supply can be automatically and efficiently carried out by natural laws.

(iii) Provided that man permits the application of these laws the distribution of water can be efficiently carried out by him in such localities where physical conditions do not prohibit it.

(iv) If, on the other hand, interference with these laws is permitted the water supply is liable to become deficient or irregular and its distribution impossible or at least difficult.

(v) It is necessary therefore to aid the forces of nature in this respect and when necessary to prohibit such action as hinders or diminishes these forces with a view to reaping their full benefit in those localities where this may be possible.

Some Indian facts agreeing with the results of European research.

So much for Indian theories advanced on, it is thought, the sound basis of European facts. We will now present some Indian facts in order to strengthen, if considered necessary, the arguments set forth and though, as before stated, Indian records are very incomplete, yet some statistics are available that may aid us in arriving at the desired end.

Unfortunately in India the investigations of past years were designed chiefly to prove that afforestation increased the rainfall of the country. It has been shown that in France it has this result and it will later on be proved that in India instances have occurred where this is the case in a still more marked degree, but to our mind this advantage though important is quite insignificant compared with the effects of forests in storing and regulating the present water supply which, if not allowed to run to waste as so frequently is the case, is probably still ample enough in many places to assure the success of agriculture and of other industries where these are now dependent on local rainfall. It is not proposed therefore to lay any very special stress on the duty of increasing the present rainfall though the proper afforestation of catchment areas will undoubtedly incidentally lead to that result.

It was in Madras, for the reason that this province was probably more advanced than any in India at that time, that attention was first devoted to "the effects of trees on the climate and productiveness of a country." In 1846 Dr. Gibson, then Conservator of Forests, drew attention to the rapid denudation of wooded areas and to the effect thereby produced in the drying up of springs and in the general falling off in fertility of the country. He referred principally to his observations in the districts of South Konkan and Canara, and the following year the Directors of the Honourable East India Company addressed the Government of India asking, in the terms above quoted, for investigation. The few reports made public as the result of this enquiry supported to a great extent Dr. Gibson's contention, and it was shown that extensive clearances had affected the water supply so that in some districts tanks and wells had run dry, while dry cultivation had much increased. But the enquiry did not apparently extend over any large area and the subject was, it seems, soon lost sight of.

In 1877 a great famine raged in Southern India and Sir R. Temple, who was deputed to the aid of the Madras Government, wrote as follows :—

> "We cannot but reflect whether the uncertainty of season, which often proves so disastrous in Southern India, is not becoming worse and worse; whether there may

> not be some physical causes at work to render the rainfall precarious; and whether such causes can be ascertained and obviated. It is hard to conceive a question more practically important than this. The discussion of it would be beyond the scope of this minute. But, connected with it, there is one particular matter which may be mentioned forcibly, though briefly. The Southern Peninsula of India has been, or is being, denuded, not only of its forests but also of its jungles, its groves, its brushwood, its trees. The denudation has been, as I understand, going on near the sources and in the upper courses of the many rivers which water the country. This, perhaps, is being in some degree checked. But with the progress of coffee planting, and with the assertion of commercial rights on behalf of the people, the utmost vigilance will be needed to keep it within bounds. If it were to proceed unchecked, there would be imminent danger of the rivers running dry........ And as these rivers supply the great canal systems, this danger has only to be mentioned in order to be felt. The same argument applies in a lesser degree to the tanks or lakes, which are second only to the canals in usefulness for irrigation......... Beyond the ghat mountains, in Bellary and Kurnool, the treeless, shrubless aspect of the country is as wonderful as it is melancholy. These are the very districts where famine has been occasionally epidemic, and where scarcity has been almost endemic."

In the following year the "Indian Famine Commission" was appionted and submitted a report in 1880. Here was excellent opportunity to interest both the State and the public in a matter of national importance, but it was not taken. From the three pages devoted to Forest Conservancy the following extracts will show how the subject was disposed of and what was the importance attached thereto.

> "The question of the influence which the denudation of forests may have upon the rainfall and on the subsequent retention of the rain-water in the soil, and its effect on the permanence of springs or flowing streams, is among those on which our opinion has been asked. Whether the presence or absence of forests has any direct effect in precipitating rain, is a much disputed point which we shall not attempt to decide; but there is before us a great amount of evidence from all parts of India that the destruction of forests is believed to have acted injuriously by allowing the rain-waters to run off too rapidly. They descend from the hill-sides in furious torrents, which carry down the soil, cause landslips, and form sandy deposits in the plains, so that the surface drainage, which, if gently and evenly distributed over an absorbent soil protected by vegetation, should furnish a perennial supply of fertilising springs, passes rapidly away, and the streams into which it collects quickly cease to flow, after causing mischief instead of good......
>
> "So far as any immediate advantage is to be sought from the extension of forest in respect to protection against drought, it will, in our opinion, be mainly in the direction of the judicious inclosure and protection of tracts.... from which improved and more certain pasture may be secured for the cattle of the vicinity, a supply of firewood secured which may lead to a more general utilization of animal

manure for agriculture, and a possible addition made to the power of the subsoil to retain its moisture, and to the prospect of maintaining the supply of water in the wells .... As to the protection of the higher hill slopes from denudation, it may confidently be stated that they will, in any case, be more useful if kept clothed with wood than subjected to the wasteful and destructive process by which they are brought under partial and temporary cultivation, and that, whether the expectation of an improved water-supply as a consequence of such protection is fully realised or not, there is on other grounds sufficient reason for arranging for the conservation of such tracts where it is practicable."

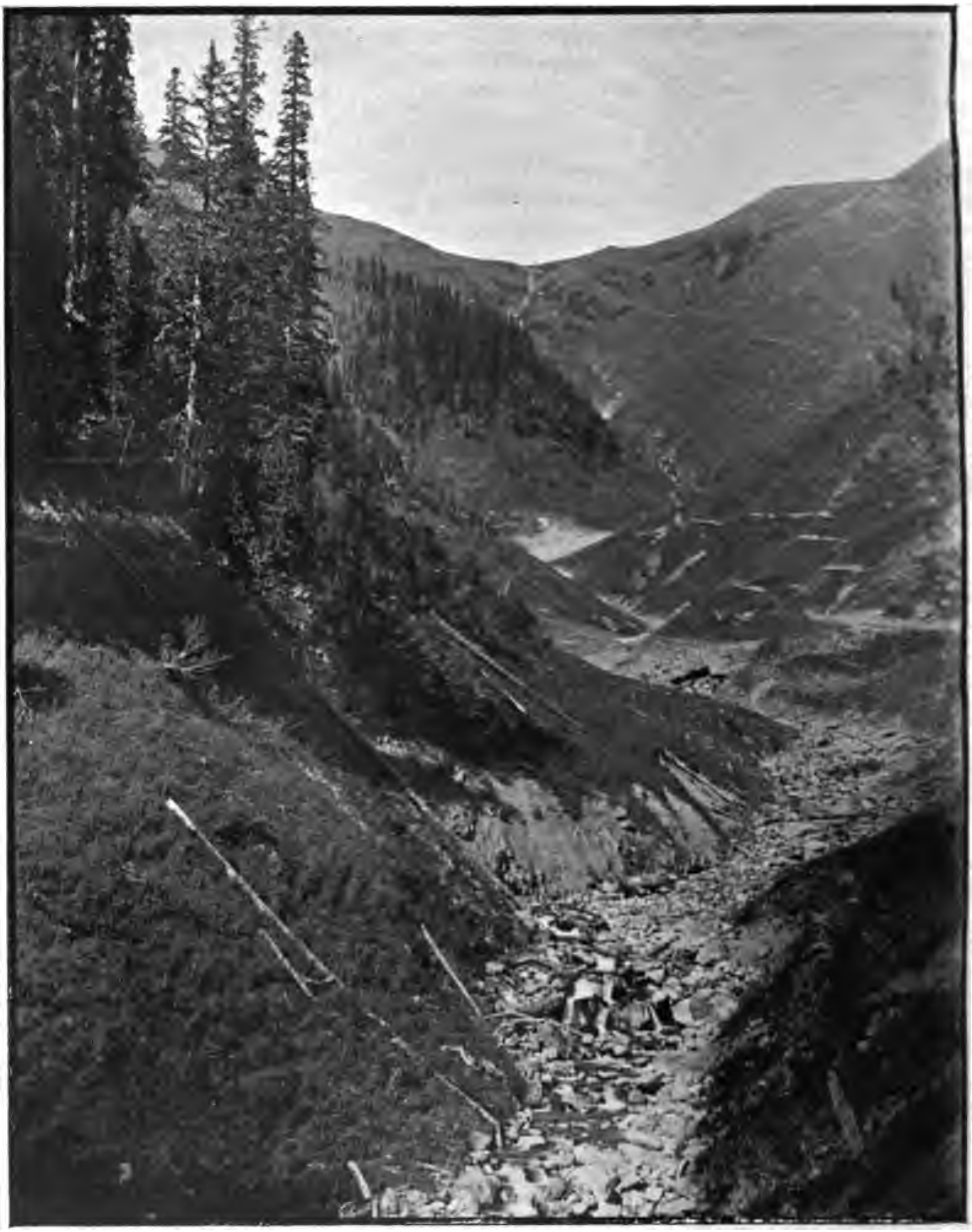
Meanwhile the destruction of forests continued unchecked, it having not yet been acknowledged that the success of agriculture was to any great extent bound up in their maintenance, though there was an almost unlimited amount of evidence available from other countries to prove that this was the case. In 1884 Sir D. Brandis wrote :—

"Whatever views may be held regarding the effect of forests in regulating the surface drainage, and in improving the water-supply in springs, rivers, tanks and wells, there is no doubt that on hills clothed with forest the soil is protected, that less soil is washed away, and that less sand and silt are carried down by the rivers. There is not a district in the moister regions of India where the effects of denudation in this respect are not visible. The sand which is washed down from the denuded hills in the Hoshiarpur district of the Punjab has destroyed the fertility of large areas, and ravines and torrents are numerous in the more thickly inhabited portions of the Himalaya. Even in the Nilgiris the evil will be felt sooner or later, although these hills are favoured beyond any hill range in India by gentle slopes, deep soil, and a moderate rainfall; every year masses of fine silt, which, if retained, might be a source of wealth to the European planter as well as to the native cultivator, are washed down from them into the rivers. The Ratnagiri district on the western coast, south of Bombay, is almost bare to the crest of the ghats, and the effect of denudation has shown itself by the silting up of the streams which rise in the ghat mountains, and run a short course to the sea; some of these rivers were formerly important for the trade of the country, but now they are only navigable for small boats. The benefits, direct or indirect, which the people of India will derive from forest conservancy, if continued in a systematic manner, can hardly be overrated."

And long before this in 1870-71 the forest report for that year described in the following terms the state of the forests of Kashmir which form the catchment area of three great Indian rivers, the Indus, the Jhelum and the Chenab. The writer inspecting these forests 35 years later found that much still remained to be done to secure even a partial efficiency of these catchment areas.

"The Kashmir forests everywhere exhibit the most wasteful system of working. The trees are felled in easy places wherever it is possible, without any reference to

PLATE III.



Eardly-Wilmot.—Influence of Forests.

PROTECTIVE FOREST VEGETATION,
at 11000 feet elevation.

[To face page 28

> the protection of the remaining stocks, or to shelter for reproduction ; forest fires are allowed to rage uncontrolled ; and, with heavy demands on the market, these forests will in all probability soon be ruined, so far as reproduction is concerned. Our own plains in the Punjab are watered by the rivers which flow from the Kashmir hills, and if the latter are denuded of timber, disastrous results will assuredly follow from time to time in the country below them, in the shape of alternative droughts and floods, results which have actually occurred in France on several occasions during the present century, owing to the denudation of trees on the Alps."

Let us see how the Indian Meteorological Department approached the question. In 1885-86 Mr. Blanford showed in his Annual Report that in the Central Provinces prevention of shifting cultivation followed by Fire Conservancy had in 10 years increased the rainfall over the affected area by 6·81 inches as recorded at 14 stations. In 1887 he wrote as follows :—

> " The general conclusion to be drawn from the facts set forth in the foregoing pages is that, while no instance cited fulfils the requirements of scientific proof; the tendency of the evidence they afford is uniformly favourable to the idea that the presence of forest increases the rainfall. Firstly, they help to store the water by protecting the soil and so keep up a constant evaporation ; and, secondly, by checking and obstructing the movement of the wind, they prevent the evaporated vapour being carried away, and tend to produce that calm state of the atmosphere that is favourable to ascending currents and local precipitation."

In his report for 1893-94 Sir John (then Mr.) Eliot noted, on the observations then being carried out in Baluchistan, in Ajmer and in the North-West Provinces to prove that afforestation increased the rainfall, that it was doubtful whether it was desirable to continue them and that the only way to obtain reliable results was to compare observations over a large area before and after it had been planted up which would take many years. This conclusion was doubtless correct, but it appears from Dr. Volcker's Report on the " Improvement of Indian Agriculture " that elsewhere Sir J. Eliot had already had an opportunity of doing this, for when in the Nilgiris in 1891 he had proved from the Rain Records of 20 years that since the afforestation of Ootacamund, taking the local rainfall of March, April and May for a five year period, the number of rainy days had increased by 26 and the rainfall by 3 inches ; and again that, excluding the three monsoon months of June, July and August from the calculation, there were in five years after afforestation 42 more rainy days, and that light regular showers had taken the place of destructive occasional torrents.

Next comes in 1893 Dr. Volcker's report and what he writes on the influence of forests on agriculture is quoted below :—

"The beneficial influence of irrigation in dry tracts is obvious, but that resulting from the growing of trees needs some explanation.

"It has been much debated whether forests and plantations do actually bring about an increase of rainfall or not. But I would point out that their real influence and value consist in their lowering the temperature and thus causing moisture to be deposited where otherwise it would pass on. As a consequence of this, forest and plantations will cause rain to fall in gentle showers instead of in heavy and often destructive deluges. Thus, a given quantity of rain will be distributed over a greater number of days, and its value to the agriculturist will be thereby largely increased. The true test of the value of afforestation in this connection is not so much whether the total rainfall be increased, but whether the number of rainy days be more. The dewfall is also increased in the neighbourhood of trees, and this has considerable agricultural importance too.

"It has not unfrequently been observed that in times of drought there has been plenty of rain in the clouds overhead; what was wanted was some agent to condense and 'bring it down.' Trees would materially assist in performing this. Again, the difference between the action of a gentle rain and that of a heavy deluge is very marked: for, while in the former case the water sinks gradually into the soil, in the latter it rapidly runs off the baked surface of the earth, and very often causes much damage by the destruction of roads, the washing away of bridges, and the silting up of tanks.

"But there are other indirect benefits attending the spread of tree-planting, benefits affecting the soil itself more particularly. What trees do is to hold up the soil, preventing it from being washed away and carried off by streamlets; next, a coating of vegetation soon covers the soil on which trees are growing, and binds it all together, though, at the same time, rendering it permeable to, and retentive of, moisture, so that the rain no longer flows off as it would over a hard and dry surface without benefiting the soil below. Thus, a cool surface is produced in place of an otherwise dry and heated one on which the sun's rays would impinge directly, and from which they would be reflected; shade and shelter are provided, and in the end a moister climate will prevail. From old records and descriptions of India there is reason to believe that the climate was not formerly what it now is, but that the spread of cultivation, accompanied, as it has been, by the wholesale and reckless denudation of forests and wooded tracts, without reservation of land to afford good wood or grazing, has done much to render the climate what it now is. Sir William Denison states that, when Governor of Madras, he was shown districts in which the rain had retreated as the forests had been cleared back, and he points out that when a rain cloud comes in contact with the bare and heated soil the tendency is for the moisture to be held up in suspension in the air, and not to be deposited on the earth. Such districts were found in Cuddapah, Madura, and Travancore."

Two years later Mr. J. Nisbet contributed to the literature of the subject in an article on "Forest Meteorology" published in the

Calcutta Review for July 1895 in which much useful information has been collected and to some extent utilized in the preparation of the present article. Mr. Nisbet eleven years later again drew attention to the importance of this neglected subject and urged the appointment of a committee of enquiry.

Lastly, let us see what has been done to elucidate this question by the commissions appointed in recent years.

The reports of the Famine Commissions of 1898 and 1901 omit all reference to forests save as a means of possibly affording grazing to cattle in times of scarcity and that of the Indian Irrigation Commission of 1901-1903 ignores the influences of forests on rainfall and on water storage. But in the latter compilation there is much of interest connected with the subject under consideration, a portion which may usefully be summarized in these notes. From it we learn that excluding Burma and the Himalaya, the average rainfall over the whole of India is about 42 inches and that the greatest variation recorded have not exceeded 7 inches. But this average rainfall is liable to very great local variations and the annual rainfall again still more so, less than ¼th of the normal annual amount having been sometimes locally recorded in years of extreme drought. For statistical purposes India, excluding the catchment basins of the Brahmaputra, the Irrawadi and other Burma rivers, and also Baluchistan west of the Indus, is shown to have an average annual rainfall of 37½″, and of this it is stated that about 41 per cent. flows off the surface of the soil (of which 6 per cent. is utilized in irrigation and 35 per cent. runs to waste into the sea), while the remaining 59 per cent. is reckoned as absorbed by the soil or lost by evaporation. (It is, however, open to question whether 35 per cent. represents the total waste from surface flow, for the direct loss in areas not covered by forest vegetation is in other countries very considerably higher.)

The difficulties of utilizing a larger proportion of the surface flow of water are explained so as "to prevent any over sanguine expectations of the utilizations in irrigation of the enormous volumes of water carried off by the Indian rivers," but in stating "the main conditions imposing a limit to the use which can be made of the surplus drainage of the country for the prevention of famine " it seems appropriate to point out that if this surface flow cannot be utilized it would be but rational to endeavour to reduce it by absorption into the soil thereby to produce perennial springs and streams and to raise the water level so that irrigation by one means or another might become possible in some localities where this is not at present the case.

The difficulties alluded to in the preceding paragraph are :—

(*a*) *The limitation imposed by the distribution of the rainfall* but it has been shown that afforestation may increase the rainfall and make it more equable.

(*b*) *The difficulties connected with the surface conformation.* Chiefly in connection with surface storage; subterranean storage is not considered.

(*c*) *Impossibility of conserving water for a year of drought.* Again, chiefly in connection with surface storage, ignoring that it may take several consecutive years of deficient rainfall to dry up a perennial stream, provided that its catchment area is in proper order, and has received the rainfall of previous years and regulated its off flow.

(*d*) *Unsuitability of soil* for irrigation ; here is nothing affecting forestry save that a large proportion of the unsuitable area consists of forests.

(*e*) *Territorial difficulties* in the way of irrigation will, it is said, be found capable of friendly adjustment, just as it is hoped that the same difficulties with regard to afforestation of catchment areas will disappear.

The report next considers *the limiting effects of the conditions in certain river basins.* The first example is that of the Palar river in Madras of which it is said that almost the whole of the rainfall over an area of 9,000 square miles is stored in tanks or diverted into canal channels, so that there is but little surplus flow from the basin of the river. And yet the districts which lie in this area, Chingleput, North Arcot and East Kolar, are liable to periodical famine.

Let us examine the latest accounts of two of these districts. We shall find that in them agriculture is almost entirely dependent on the storage of local rain water in tanks, and that the rivers are unreliable. Both districts appear to afford examples of the advantages forests should confer either by increasing the rainfall or encouraging the flow of perennial streams.

Chingleput—Rainfall neither copious nor regular, average 45", chiefly from the north-east monsoon. The district has little forest growth, mostly it consists of low scrub occupying some 214 square miles, except in the hills where there is some timber; 702 square miles are irrigated of which 619 square miles from tanks, mostly rain fed. The crops are always more or less precarious as agriculture is dependent on local rainfall.

North Arcot—Rainfall average 37" forests about 1,291 square miles; 45 per cent. of the cultivated area is irrigated, amounting to 559 square miles; of this area 60 per cent. is fed from small tanks dependent on precarious local rainfall and 40 per cent. from dams across rivers, also precarious, as the course of the rivers are short and their flow is largely dependent on local rainfall. Famine is frequent.

The physical obstacles in the way of extension of irrigation are amply set forth in the remainder of this section where the question of artificial storage of water, sometimes on a vast scale, is touched upon. But no mention is made of a recognized fact that in order to maintain these reservoirs at a useful level the protection of the source of supply is necessary, first, so that the rainfall shall not diminish, secondly, that it should be given off fully and equably during the year so as to maintain a constantly available water supply, and lastly so that the reservoirs shall not be silted up by torrential discharges from the catchment areas.

With regard to the *extension of well irrigation* certain limits are also imposed. Those limits are the amount of the subsoil supply of water, its depth below the surface, the ease with which construction can be carried out, and the consequent cost of constructing the well and raising the water. It appears to follow that if the amount of subsoil water is increased and the spring level raised the area under well irrigation could also be increased, and these two conditions would be the result of the natural storage of water by means of suitable afforestation and might be induced thereby in more localities than at present.

It cannot be denied that there are many tracts which must, owing to physical and other difficulties, remain dependent on the local rainfall and it may be admitted that there are areas where the volume of the rainfall or of the wasted water affords little index to the possibilities of extending irrigation; but we think it equally certain that there are even larger areas where a perennial water supply might be secured by suitable afforestation and where the natural storage of water would result in a permanent increase of subsoil moisture so that the failure of the rains of one season would not inevitably reduce the population to starvation point.

"No means," it is said in the report," have yet been found for storing *any portion* of the enormous floods which are brought down from the Himalaya during the few months of the monsoon season." Yet we believe that the means are there and have only to be utilized. Not that floods will altogether cease even with the most careful afforestation, but it is certain that they will diminish in frequency and violence, the water flowing off during a longer period and becoming more amenable to control.

It is in any case regrettable that the investigations of the Famine and Irrigation Commissions did not include the subject of the influences of forests on the water supply of the country when this has received such ample recognition elsewhere, and also that when the term "assured rainfall" was used the reason for this assurance was not enquired into. It may well be that the areas which now receive a large and certain rainfall owe this advantage to some extent to the sudden obstacle opposed to the monsoon winds by mountain ranges more or less wooded or to the presence of vast forests still undestroyed by man. The rainfall chart of India affords some basis for this suggestion, and if it is only partially correct the "assured and heavy rainfall" of the present day might well change in the future owing to subsequent denudation of the country just as it is believed to have changed in the past.

There can be no doubt that those who have actually enquired into the influences of the forests in India have invariably been convinced that these influences exist in some form or other, though as stated more stress has been devoted to the actual increase of local rainfall than to the regulation of the water supply. When the mutual dependence and relative importance of these two factors shall have been acknowledged the facts and writings of the past will in many cases assume a new interest and importance.

The present condition of some selected districts.

As it was in the province of Madras that enquiry first began, and as from thence come many of the statistics which have been quoted in various documents proving the benefits conferred by forests, it will be of interest to quote the latest description of the present state of some of the districts of that province in order to ascertain if the evils complained of many years ago are still present and to what extent. It is regrettable that in other provinces we have not readily available similar data on which to base any conclusions, though there we can refer to the "chos" of Hoshiarpur as evidence of the evil of moving sand in disforested areas and of the necessity of protective legislation, to the plantations of Changa Manga as proving an increase in atmospheric moisture, and to the records of the Irrigation Department and of the Railways which may perhaps show that, taken over a period of years, floods are becoming more frequent and higher than formerly. With regard to the last mentioned suggestion, at the time of writing the summer head-quarters of the Government of Bengal and of the Supreme Government are both practically isolated, the former by floods in the Teesta and Dharli rivers, the latter by the effects of continuous rainfall in the denuded slopes which extend from Simla to the plains.

In the district of *Coimbatore* there are over 2,000 square miles of forests chiefly valuable as a huge grazing ground. They have suffered much from fire, and perhaps from excessive grazing. Formerly the forests were much finer. At present they form only a poor catchment area for water which is apt to flow down to the plains in sudden and destructive floods after rain. Nineteen per cent. of the district area is irrigated, of which 502 square miles from wells and 154 square miles from canals and tanks. The district suffers from constant famines owing to lightness of rainfall and absence of irrigation works. In 93 years there have been only six good seasons.

In the district of Vizagapatam the only heavy forest is on the Jeypore plateau; in nearly the whole of the rest of the district the forest has more or less been destroyed by the inhabitants; shifting cultivation in the hills and the demand for firewood and the enormous heads of goats in the plains being responsible for the denudation. As the majority of rivers flowing through the low country are short and irregular in flow they are not of importance for irrigation. Temporary dams are built across them and the monsoon floods are diverted into storage tanks. There was scarcity in the district in 1891-92, relief was necessary in 1896-97, but the district is famine-protected by its communications by land and water which are good.

In the district of Bellary the reserves consist of patches of scanty scrub jungle; tradition assigns extensive forest to the district, but none existed within the memory of man. The irrigated area is 2 per cent. of the district, half being supplied from the Tungabhadra river canals, the remainder from tanks and wells. Any shortage in the scanty rainfall is liable to produce distress and the unfortunate ryot has hardly emerged from one famine ere he is submerged in another.

In the Kurnool district there are nearly 3,000 square miles of forest to which flock the cattle of Nellore and Kistna. But the district is essentially an unirrigated area, only 4½ per cent. of the total area enjoying this advantage. Famines have occurred nine times since the beginning of last century.

And finally, as an instance of a district protected by forests from famine :—

The district of South Kanara is essentially a forest district, and the country, save on the hills near the coast which have been stripped of forest growth, is richly wooded. Shifting cultivation is prohibited. There are no Government irrigation works, the ryots most skilfully utilize the springs and streams for irrigation. The district is practically exempt from famine and no relief has ever been required save in 1812.

It is proposed to leave the reader to make what inferences appear to be desirable from the above statements and from those which follow.

Similar statistics might, as beforesaid, no doubt be furnished for other provinces. Take for instance Baluchistan: here the country is scantily clothed with vegetation and most of the hills which are not protected by other higher ranges are bare of forest growth. There are two State irrigation schemes which are dependent on rainfall and for the rest the extension of embankments to catch the rain water which flows off the stony hills is the best means of protection against famine. Actual famine is, however, unknown, but scarcity is frequent, and the greatest safeguard against this lies in the migratory habits of the people and in the proximity to protected areas.

Of more recent reports, received indeed in the current year, that of the Hon'ble Mr. S. M. Fraser, Resident in Mysore, is of importance. He states as follows:—

"It was ascertained that taking averages extending over periods of 40 or more years, the flood levels of the Kistna have shown a marked and steady increase, while hot weather levels of both the Kistna and Cauvery have shown a significant decrease in the Madras Presidency, and the Chief Engineer for Irrigation, Madras, who gave the marginal figures relative to the flood levels of the Kistna, observed that this result pointed to forest denudation."

Period.		Date.	M. F. L.	
1860-70	August	1868	63	25
1870-80	September	1874	65	45
1880-90	July	1882	66	55
1890-00	August	1896	67	55
1900-04	October	1903	71	00

Mr. O'Dwyer, Revenue Secretary to the Chief Commissioner, North-West Frontier Province, also testifies to the denudation of forest areas, as the following extract will show:—

"The danger to forest growth both within and without the State Reserves from the unrestricted increase in sheep and goats is a very serious problem. It is admitted by all officers who have held any long experience of the district—Mr. Watson, Captain Beadon, Mr. Monro—that whole tracts, *e.g.*, the Gandgar Range, the Lora and Nora ilaquas in Haripur, the Pakhli plain in Mansehra, have been absolutely denuded of forest growth within living memory from this cause, and the evil results to climate, soil, etc., which spring from such denudation are so obvious that it is needless to dilate upon them here."

In a recent issue of the *Madras Mail*, in an interesting article on Indian forestry the following statement is found:—

"Forty years ago, when the Rushikuliya Project in Ganjam was being investigated, it was found from experiments that the supply channel could be kept full of water for at least 60 days. Observations during the last five years show that it can be kept full for scarcely half that time. In 1855 Captain Philips reported magnificent forests in Kimidi, the more accessible being on both banks of the Vamshadhara river, above and below Battili, Barasinghi, Kottur, etc. And indeed the whole of the hilly tracts abound with fine trees, the only difficulty being their removal when cut; but from the more accessible forest, large quantities are sent annually, principally by water, to Calingapatam, Chicacole, Pundi, and elsewhere. Now, those forests are practically non-existent and the river is such that it would be impossibie to float large timber. A short time ago an interpellation was asked in the Madras Legislative Council anent the shortage of water in the Saradi river in Vizagapatam. The principal affluent of this river comes from the Madgol Hills, where the destruction of forest in latter years has been notorious. In 1679, in the middle of the hot weather, Mr. Streynsham Master 'forded the Kistna river (at Bezwada), which is very good water.' The Kistna District Manual tells us that in 1850 'the breadth of the river (at Bezwada) is 3,860 feet and the depth of water in summer is 6 feet.' It is now asserted that the Kistna river is not, and never has been, 3,860 feet wide and 6 feet deep in summer, but that 6 inches would be nearer the mark if spread over this width.

"In the early '80's Captain Taylor wrote of the Gundlakamma :—'This river has a perennial flow, the normal flood level is 6 feet, while a full fresh is sometimes 32 feet.' There is now no water in the hot weather below the Cumbum Tank (which was built in the fourteenth century), and hardly a foot of water in the upper reaches. Again in 1860 Captain Rundall wrote :—'The whole basin of the Hindri lies within the district of Kurnloo. Its water will, therefore, be appropriately turned to account when distributed over that district. The storage of 2,000 millions of cubic yards will ensure a daily supply of 300,000 cubic yards per hour for 180 days, much more than sufficient to maintain a first-rate navigable canal; and judging from information I have lately received renders also the Pennar quite accessible for boats drawing 3 feet of water.' The District Engineer of Cuddapah informed me that on the 13th December 1905 the Pennar was flowing 2½ feet deep at Chennur, just below its confluence with the Kunder, and that the water was just what it should be for boat navigation, neither too much nor too little. It is not a perennial stream, but comes down in freshes for short periods, and thereafter, except for a small trickle in its sandy bed, dries up again almost at once. In the '60's timber used to be floated down the Pennar from Siddhout taluq to Nellore. The idea of the Hindri ever supporting a navigable canal with its water would be utterly ludicrous if present data were taken."

The remarks above quoted have the greater significance when during the past summer the flow of the Cauvery river was reduced below the lowest estimates on which the Mysore electric power works were based, so that great expense and inconvenience were incurred by the unexpected diminution of the power delivered under contract to the Kolar Gold Fields and elsewhere. No industry necessitating a certain supply of water could profitably be started on so uncertain a flow as at present obtains in many Indian rivers.

Conclusions.

Many more instances comparing the absence of forests, or their unsatisfactory condition with the figures for irrigation and famine might be presented, but enough has perhaps been quoted to show that where forests are not maintained or do not exist and agriculture is dependent more or less entirely on the flow of the rainfall from the surface of the soil it is not sufficiently protected to afford a certain livelihood to the inhabitants.

It has been often asserted that one-fifth of the surface of the Indian Empire is covered with forest vegetation and that one-fourth of the area of British India is included in the control of the Forest Department, but from these facts it must not be inferred that the distribution of forests throughout the country is such as to efficiently control and regulate the water supply in every locality. This is far from being the case; for instance, in the United Provinces the percentage of State forests to the total area of the province is but 3·9, in the North-West Frontier Province it falls to 1·8, while in Burma it rises to 75·8, and in Assam to 45·5. Nor can it be laid down as a general rule what percentage of forest is or will be necessary to a province or district; for this depends on climatic, protective and economic demands, of which, save in exceptional circumstances, the two former are probably of the greatest public interest. In the few provinces where the forest area amounts to 20 per cent. or more of the whole, local Governments occupy a pleasant position, for they can now, with the knowledge gained in Europe and India, arrange the permanent reservation of State forests so as to secure for the future not only the available forest wealth but also at least a certain proportion of the agriculture and other industries of their territory. This no doubt is a grave responsibility, but a light one compared with the difficulties apparent elsewhere of fully utilising the already reserved areas, of preventing the wasteful action of the people so long connived at, and of afforesting new areas so as to protect the water supply and thereby indirectly to afford in many cases local security against famine or scarcity.

The importance of State irrigation in the facilities it could afford for increasing the area under tree growth has perhaps up to the present not been fully recognized or taken advantage of, yet there is probably in the aggregate a vast area in India at present supporting inferior crops or perhaps none at all which could by means of irrigation if that were available be brought under forest growth with certainty and celerity, to the great advantage in every way of the country. In many instances it might probably be comparatively easy gradually to afforest the catchment area of important streams in the plains country by the gradual extension of irrigated plantations in such cases where the mere closure and protection of such areas was not sufficient to induce a forest vegetation which would increase yearly in luxuriance and value. In this connection the Irrigation Colonies of the Punjab may be cited where opportunity has occurred and is being taken advantage of to provide a certain percentage of forest on the lands which have been rescued by irrigation from desert waste or scrub jungle. It is true that the economic value of the forest probably at first directed attention to this important policy, but there can be no doubt that another result will also follow in the improvement of climatic conditions and the fertility of the soil in the neighbourhood.

The catchment areas of many Indian rivers, as well as those of their tributaries, are in Native States, and thus outside the direct control of the Government. Especially is this the case in regard to the important rivers of Upper India which supply the chief distribution works under the control of the Irrigation Department. The Indus has its upper catchment area partly in Kashmir, the Jhelum and Chenab entirely so, the Ravi flows from Chamba and the Beas alone of the five rivers of the Punjab originates in British territory. The Ganges and some of its important affluents rise in Tehri-Garhwal, where also the Jamna has its source. Further east the Sarda, the Kauriala and Girwa, the Mohan, the Rapti and the Gandak flow from Nepal; thus all the snow fed rivers of the Punjab and the United Provinces, except some minor streams originating in the districts of Kumaon and Garhwal, are practically controlled by the Princes of various Native States in so far as the most important part of their catchment areas, that between the snow line and the point where distribution for irrigation commences, is concerned. In Northern India—the Punjab and the United Provinces—on account of the magnificent river systems, there is perhaps less absolute necessity for afforestation in the plains (though more so in the hills) than elsewhere where there are not these natural advantages, yet there are probably very many rivers and streams of local origin even in these provinces the regulation of whose flow by means of afforestation in their catchment areas would be beneficial to agriculture at all seasons of the year.

Of the principal rivers of other provinces of India a list is appended, prepared by the courtesy of Mr. R. Burn, I.C.S., Editor of the *Imperial Gazetteer*, from which details as to country of origin, whether utilized in irrigation, and other valuable information may be acquired. There again the number of rivers which rise in Native territory is worthy of remark. It has been pointed out that one reason for the occupation of the catchment area of these streams by Native States is that the hills formed the fastnesses in which warlike or other tribes took final refuge and were left unmolested at the last conquest of the country. The importance of their position is the more apparent in these times of peace and progress than in the period of anarchy which preceded them. It is not perhaps too much to say that if the flow of water in these rivers and their tributaries were constant throughout the year not only would irrigation by means of both permanent and temporary canals and channels be possible over a much wider area than at present, but also that the "spring level" outside the forest would be raised, so that even where surface irrigation was impossible on account of physical difficulties, well irrigation would become more economical and easier than it at present often is, and so over a larger area than at present absolute dependance on a favourable rainfall in each year would be avoided, to the great benefit of the country. And at the same time the yearly loss by the action of sudden floods would be much reduced.

The conclusions arrived at after the perusal of these notes must depend upon whether the facts and arguments presented are acceptable, in whole or in part, or not at all. If it is not conceded that the natural laws which regulate forest influences in Europe are applicable to India there is nothing left to say or do. If, on the other hand, it is agreed that these laws apply to the exaggerated conditions of climate and population in India a very serious responsibility is incurred.

In these days of improved communications, mortality as a direct consequence of famine has almost ceased to exist, but local scarcity must always bring with it certain drawbacks injurious to national wealth and prosperity, and the question is next for decision whether it is best to meet an oft recurring difficulty by recurring temporary alleviation or by such a policy in regard to afforestation as may result at least in some localities in its permanent prevention.

Such a result will not be arrived at even with sustained effort in the course of a few years, the more so as it will mean an interference with local interests which will take both time and money, both tact and patience effectively to introduce; it will mean too a more vigorous policy in the matter of prevention of denudation, but if there is faith in the remedy the results to be attained are possibly worth any effort and expense that may be entailed.

In these Notes it has nowhere been asserted or even suggested that afforestation is everywhere possible, or that if it were, it would result in the entire prevention of famine and scarcity throughout India, nor that the presence or absence of forest vegetation is the sole factor regulating the even flow of rivers in this connection. We are in accord with Mr. W. B. Greely of the U. S. A. Forest Service whose remarks are quoted below:—

> "In the discussion of the relation of forests to stream-flow there is a danger of over estimating the influence of forest cover upon the character of a stream to the exclusion of other factors of equal or greater importance. It is a mistake to assume that the denuded or wooded condition of a water-shed is of necessity the controlling factor in determining the behaviour of the stream; that a forested stream is necessarily regular in flow and a deforested stream necessarily irregular. In any discussion of this subject it must be recognized at the outset that forest cover is but one of a number of far reaching factors whose combined influence produces a stream of a given character, and great care must be taken not to attribute to the presence or absence of forest cover upon drainage basins results which may primarily be due to other causes."

But it is thought that there are very many localities whose treatment on approved principles would result in the creation of a permanent water supply so that the total area adequately protected against famine and flood might be very largely increased, and, if the writer is permitted to express an opinion, it is not by investigation of the degree of influence of Indian forests on Indian agriculture that a first successful step will be made towards reaching the desired goal, but rather by the appointment of local commissions to report on the present condition of the catchment areas of our rivers and on the measures that are necessary to make more of them efficient for the storage and regulation of the water supply of the country.

It is for others to write on the necessity of a permanent and regular water supply for industrial purposes. In India hydraulic power is largely available and little used, chiefly on account of the difficulty of control. When that difficulty is surmounted in the manner indicated in these Notes it will not be rash to predict that here, as in other countries, national wealth will increase with the utilization of indigenous products which are now either unnoticed or held to be of little value.

APPENDIX I.

Principal Rivers outside the Provinces of the North-West Frontier, Punjab, and the United Provinces.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
		Assam.		
1. Ai	Enters British territory in Goalpara District.	......	Bhutan	A tributary of Manas.
2. Barnadi	Enters Assam in	26° 13′N. & 91°48′E.	Himalayas	......
3. Bharali	Enters British territory in Darrang District.	......	Ditto	......
4. Bogapani	Shillong peak	......	Khasia Hills	......
5. Bhogdai	Nāgā Hills District.	......	Nāgā Hills	......
6. Brahmaputra	Enters British territory near Sadiya.	......	Tibet	......
7. Champāwati	Enters British territory in Goalpara District.	......	Bhutan	A tributary of Brahmaputra. Course, 125 miles.
8. Dhānsiri	Enters British territory in Darrang District.	......	Towang (Tibet).	......
9. Dhānsiri	Nāgā Hills District.	......	Nāgā Hills	......
10. Dhaleswari	Lushai Hills	......	Assam	A tributary of Surma. Total length, 180 miles.
11. Dihang	Bomjur (out post)	......	Himalayas	These rivers, though large, are only feeders of Brahmaputra, which they join at or near Sadiya, and thus are not of much importance.
12. Dihang	......	.. ...	Ditto	
13. Digru	Khasi Hills	......	Khasi Hills	A feeder of Kalang.
14. Dihing, Buri	Patkai Range	......	Patkai Range	......

APPENDIX I—*contd.*

Principal Rivers outside the Provinces of the North-West Frontier, Punjab, and the United Provinces—contd.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
		Assam—*contd.*		
15. Dihing, Noa .	Singhpo Hills .	......	Assam . .	These are small rivers; the former has very little connection with Assam, as it falls east of Sadiya, while the latter is a small stream in the southern half of Lakhimpur District, and falls into Brahmaputra below Dibrugarh.
16. Dibru (or Sonāpur).	......	......	......	
17. Dikho . .	......	......	Hills inhabited by independent Nāgās.	......
18. Disāng . .	......	......		......
19. Jadukata .	Enters British territory in Sylhet.	......	Khasi Hills .	......
20. Jatinga . .	Hāflong, North Cāchār Hills.	......	Assam . .	......
21. Jhānzi . .	Mākokchang .	......	Nāgā Hills .	......
22. Jinjram .	Urpad *bhil* (Goalpāra).	......	Assam . .	Falls in Brahmaputra. Course, 120 miles.
23. Jiri . .	Barail . .	......	Ditto	Falls in Surma. Course, 75 miles.
24. Kapili . .	Jaintia Hills .	......	Jaintia Hills.	......
25. Khowai .	Enters British territory in Sylhet.	......	Hill Tippera.	......
26. Kulsi . .	Little west of Shillong.	......	Khasi Hills .	Joins Brahmaputra near Kāmrup.
27. Langai . .	South of Sylhet District.	......	Assam . .	......
28. Manas . .	Bhutan Hills .	......	Bhutan .	......
29. Manu . .	Enters British territory north-west of Sylhet District.	......	Hill Tippera.	......

APPENDIX I—*contd.*

Principal Rivers outside the Provinces of the North-West Frontier, Punjab, and the United Provinces—contd.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
		Assam—*concld.*		
30. Sankosh .	Enters British territory on the boundary between Jalpaiguri and Goalpara.	...	Bhutan .	Falls in Brahmaputra. Course, 200 miles.
31. Saralbhanga .	Enters British territory in Goalpara District.	...	Ditto .	Falls in Brahmaputra. Course, 81 miles.
32. Sonai . .	Lushai Hills .	...	Assam .	Falls in Surma. Course, 60 miles.
33. Subānsiri .	...	...	Tibet (supposed).	......
34. Surma . .	Enters British territory at Tapaimukh.	...	Manipur .	Falls in Brahmaputra. Course, 560 miles.
35. Umiān . .	North of Maoflang.	...	Khasi Hills .	Falls in Kapili. Course, 81 miles.
36. Sinla . .	Lushai Hills .	...	Lushai (Assam).	After a course of 45 miles it falls into the Son lake, and emerging this it is known as Kachuyā and falls into Kusiyārā, a branch of the Surmā.
37. Someswari .	North of Turā Station.	...	Garo Hills (Assam).	Falls into Kāngsa river after a course of 88 miles.
		Bengal.		
1. Baitarni. .	Keonjhar State .	21°28′N. & 85°33′E.	Bengal (Orissa).	These two unite at Balasore and make Dharma, which falls into the Bay.
2. Brahmani .	Gangpur " .	22°15′N. & 84°47′E.	Bengal (Chota Nagpur).	
3. Barākar. .	Chota Nagpur .	24°7′N. & 85°18′E.	Bengal .	Tributary of Damodar.
4. Damodar* .	Ditto .	23°7′N. & 84°41′E.	Ditto .	Falls in Hooghly.
5. Dharma. .	Balasore . .	20°45′N. & 86°49′E.	Ditto .	Falls into the Bay of Bengal.

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* Utilized for irrigation purposes.

APPENDIX I—*contd.*

Principal Rivers outside the Provinces of the North-West Frontier, Punjab, and the United Provinces—contd.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
		Bengal—*concld.*		
6. Fenny . .	Hill Tippera .	23°20'N. & 91°47'E.	Eastern Bengal and Assam (Hill Tippera).	Falls into the Bay of Bengal. Course, 72 miles.
7. Gandak . .	Sapt Gandaki .	27°27'N. & 83°56'E.	Nepal . .	Falls in the Ganges at Sonpur in Bihar.
8. Jamuna . .	Dinājpur District.	25°38'N. & 88°54'E.	Eastern Bengal and Assam.	Falls in the Ganges. Course, 89 miles.
9. Karatogā .	Baikuntpur jungle (Jalpaiguri District).	26°51'N. & 88°28'E.	Ditto .	Falls in the Halhalia. Course, 214 miles.
10. Karnaphuli .	Chittagong Hill Tracts.	22°53'N. & 92°27'E.	Ditto .	Falls in the Bay of Bengal. Course, 121 miles.
11. Kosi . .	*Sapt* Kosikī .	26°27'N. & 87°6'E.	Nepal . .	Falls in the Ganges. Course, 84 miles.
12. Mahānandā .	Mahālidram (Darjeeling District).	26°56'N. & 88°20'E.	Bengal .	Falls in the Ganges.
13. Mātāmuhari .	Arakan and Chittagong Hill Tracts.	21°14'N. & 92°36'E.	Eastern Bengal and Assam.	Falls in the Bay of Bengal. Course, 96 miles.
14. Phulghur .	Bogra District .	24°38'N. & 89°29'E.	Ditto .	......
15. Rupnārāyan .	Manbhum District.	...	Bengal .	Falls in Hooghly.
16. Sangu . .	Arakan and Chittagong Hill Tracts.	21°13'N. & 92°37'E.	Eastern Bengal and Assam.	Falls in the Bay of Bengal. Course, 168 miles.
17. Subarnrekha .	Ranchi . .	23°18'N. & 85°11'E	Bengal .	Falls in the Bay of Bengal. Course, 296 miles.
18. Tista . .	Chatamu Lake .	28°2'N. & 88°44'E.	Tibet . .	......
19. Torsa . .	Tang Pass . .	27°49'N. & 89°11'E.	Ditto .	Falls in the Brahmaputra. Course, 245 miles.

APPENDIX I—*contd.*

Principal Rivers outside the Provinces of the North-West Frontier, Punjab, and the United Provinces—contd.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
		Berar.		
1. Penganga .	Deulphat, Buldana District.	20°31'N. & 76°2'E.	Berar . .	It is joined by the Wardha. Course, 200 miles.
2. Pūrna . .	Gawilgarh Hills .	21°36'N. & 77°36'E.	Ditto . .	Falls in Tāpti.
		Bombay.		
1. Banās . .	North east of Mount Abu.	...	Rājputāna .	Falls in the Rann of Cutch.
2 Bhīma * . .	Shrine of Bhīma Shankar.	19°4'N. & 74°34'E.	Bombay .	......
3. Mahī . .	Amjhera District	......	Gwalior (Central India).	Falls near Surat. Course, 300—350 miles.
4. Narbadā .	Amar Kantak .	22°41'N. & 81°48'E.	Rewah (Central India).	Falls in the Gulf of Cambay.
5. Sābarmati* .	Mewar . .	......	Udaipur (Rajputāna).	Falls in the Gulf of Cambay. Course, 200 miles.
6. Saraswati .	Near the shrine of Amba Bhawāni.	......	Rājputāna .	Falls in the lesser Rann of Cutch, near Anvarpur.
7. Tāpti . .	Multai (Sātpura)	20°48'N. & 78°15'E.	Central Provinces.	Falls near Surat. Course, 436 miles.
		Burma.		
1. Chindwin .	Hukawng . .	27th parallel of latitude.	Extreme north of Burma.	It is not certain whether Tanai or Tawan, which unite to form the main river, is to be taken as parent source, but it may be said to have its origin in the hills that surround the Hukawng valley.

Utilized for irrigation purpose,

APPENDIX I.—*contd.*

Principal Rivers outside the Provinces of the North-West Frontier, Punjab, and the United Provinces—contd.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
		Burma—*concld.*		
2. Irrawaddy	Myitkyinā	28th parallel of latitude.	Extreme north of Burma.	The two streams N' Maikha and Malikha rise in the extreme north of the Province and unite a point 30 miles north of the town of Myitkyinā. From the confluence the united stream southwards is known as Irrawaddy.
3. Kaladan	Chin Hills	......	Chin Hills (Yahow Country).	......
4. Mekong	Kengtung	20° 30' & 21° 30' N. (the place where it enters British territory).	Tibet	......
5. Myitnge	North Hsenwi	23° 18'N. & 98° 23'E.	North Shan States (Burma.)	......
6. Fegu	Pegu District	......	Burma	......
7. Rangoon	Near Inma Lake (Prome District).	......	Ditto	......
8. Salween	Unexplored territory to the east of Tibet, far north, to the sources of Irrawaddy.	32nd or 33rd parallel of latitude.	Unexplored territory east of Tibet.	.....
9. Shweli	Enters British territory through the State of Mōngmit.	......	China (near Tengyüeh).	......
10. Sittang	Yamethin District	20th parallel of latitude.	Burma	......
11. Taping	Enters British territory in Kachin Hills and Bhamo District.	25th ditto ...	China	.....

APPENDIX I—*contd.*

Principal Rivers outside the Provinces of the North-West Frontier, Punjab and the United Provinces—contd.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
		Central India.		
1. Betwā*	Kumri (Bhopal)	22°55'N. & 77°43'E.	Central India	Joins the Jumna. Course, 190 miles.
2. Chambal	Mhow Cantonment.	22°27'N. & 75°31'E.	Ditto	Joins the Jumna. Course, 650 miles.
3. Dhasān*	Bhopal State	23°32'N. & 78°30'E.	Ditto	Joins the Betwa.
4. Kali Sindh*	Barjhiri	22°36'N. & 75°25'E.	Ditto	Joins the Chambal. Course, 225 miles.
5. Ken*	Kaimur Range	23°54'N. & 80°10'E.	Ditto	Joins the Jumna. Course, 230 miles.
6. Pārbati*	Makgardha (Bhopal State).	22°52'N. & 76°39'E.	Ditto	Joins the Chambal. Course, 220 miles.
7. Sindh	Sironj (Tonk)	24°N. & 77°31'E.	Malwa, Central India.	Joins the Jumna.
8. Sipra*	Kokri Bardi Hill	22°31'N. & 76°E.	Ditto	Joins the Chambal.
9. Tons (Southern).	Maihar State	24°N. & 80°25'E.	Central India	Joins the Ganges. Course, 165 miles.
		Central Provinces.		
1. Mahānadi*	Sihāwa village at Raipur.	20°9'N. & 81°58'E.	Central Provinces.	Falls in the Bay of Bengal. Course, 550 miles. (20°18'N. & 86°43'E.)
2. Prānhita	Seoni, District Chāndā.	19°36'N. & 79°49'E.	Ditto	Formed by the junction of Wardha and Wainganga at Seoni.
3. Son*	Amarkantak	22°42'N. & 82°4'E.	Rewah (Central India).	Joins the Ganges. Course, 487 miles.
4. Sonār	Saugar District	23°22'N. & 78°37'E.	Central Provinces.	Joins the Ken. Course, 116 miles.
5. Wainganga	Partābpur or Mundāra, District Chāndā.	21°57'N. & 79°34'E.	Ditto	Joins Wardha at Seoni. Course, 360 miles.
6. Wardha	Multāi (Betul District).	21°50'N. & 78°24'E.	Ditto	Joins Wainganga at Seoni. Course, 290 miles.

* Utilized for irrigation purposes.

APPENDIX I—*contd.*

Principal Rivers outside the Provinces of the North-West Frontier, Punjab and the United Provinces—contd.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
		Hyderabad.		
1. Mānjra*	Bhir District	……	Hyderābād	Joins the Godavari. Course, 387 miles.
2. Musi*	Atrāf Balda District.	……	Ditto	Joins the Kistna. Course, 150 miles.
		Madras.		
1. Cauvery*	Brahmagiri	12°25'N. & 75°34'E.	Coorg	Falls in the Bay of Bengal. Course, 475 miles.
2. Godavari*	Trimbak (Nasik District).	……	Bombay	Falls in the Bay of Bengal. Course, 900 miles.
3. Hagari*	East of Kadur	13°32'N. & 76°6'E.	Mysore	The two streams, Vēda and Avati, unite at a point east of Kadur, and the united stream is called Hagari, which after course of 280 miles joins the Tungabhadra.
4. Kistna*	Mahābaleshwar	18°1'N. & 5°41'E.	Bombay	Falls into the Bay of Bengal. Course, 800 miles.
5. Pālār*	Nandidroog	……	Mysore	Falls into the Bay of Bengal. Course, 230 miles.
6. Perner*	Channarāyanbatta.	……	Ditto	……
7. Ponnaiyār*	Channarāyanbatta.	……	Mysore.	Course nearly 250 miles.
8. Rushikulya	Rushimals hills near Daringabadi.	19°55'N. & 84°8'E.	Madras	Falls into the Bay of Bengal in 19°22'N. & 85°4'E. at Ganjam town.
9. Tāmbraparni*.	Agastyama	8°37 & 77°15'E.	Ditto	Falls into the Gulf of Mana in 8°40'N. & 78°9'E.

* Utilized for irrigation purposes.

APPENDIX I—*concld.*

Principal Rivers outside the Provinces of the North-West Frontier, Punjab and the United Provinces—concld.

Name of river.	Name of place near source.	Latitude and Longitude.	Province or State in which the river rises.	REMARKS.
Madras—*concld.*				
10. Tungabhadra*	Kudali (Shimoga District).	14°N. & 75°43'E.	Mysore	The two streams Tunga and Bhadra unite at Kudali, and the united stream joins the Kistna after a course of about 400 miles.
11. Vaigai*	Border of Madura and Travancore.	10°N. & 77°31'E.	Madras	Formed by two streams; falls in the Bay of Bengal in 9°20'N. & 79°1'E.
12. Velvellār*	Southern border of South Arcot.	...	Ditto.	Formed by two streams which rise in the Salem District and unite near the Southern border of South Arcot District. It falls into the Bay of Bengal at Porto Novo, in 11°32'N. & 79°46'E.
Mysore.				
1. Arkāvati	Nandidroog.	...	Mysore	An affluent of Cauvery. Course 120 miles.
2. Hemāvati*	South-west of Kadur District.	...	Ditto.	An affluent of Cauvery. Course, 160 miles.
3. Honnu-hole*	Coimbatore.	...	Madras	An affluent of Cauvery. Course, 50 miles.
4. Kabhani*	Wynaad	......	Ditto.	An affluent of Cauvery.
5. Lakshmantirtha*	Brahmagiri	......	Coorg	An affluent of Cauvery. Course, 70 miles.
Rajputana.				
1. Banas	Udaipur	25°3'N. & 73°28'E.	Rajputana	Joins the Chámbal.
2. Bānganga*	Jaipur	27°54'N. & 76°12'E.	Ditto	Joins the Jumna. Course, 235 miles.
3. Lunio*	Ajmere City	26°5'N. & 77°37'E.	Ditto	Falls in the Rann of Cutch.

* These rivers are utilized for irrigation purposes.

APPENDIX II.

Some short Extracts from Proceedings of the American Forest Congress, 1905.

I.

Work of the Geological Survey in mapping the Reserves, by Charles D. Walcott, Director of the United States Geological Survey.

* * * * *

A branch of the Geological Survey which has been much concerned with the forests and their preservation is the hydrographic. It is now understood by everybody that the occurrence and control of waters above and below the earth's surface are largely dependent on woodland conditions. The protection of the forests and woodlands is one of the first matters tobe considered in any water-supply problem, and the study of the quantity and quality of water available for irrigation, power, and domestic and municipal purposes touches the domain of the forester.

In 1888 the Director of the Survey was authorized to investigate the extent to which the arid lands might be reclaimed. Surveys of reservoir sites and of the catchment basins of streams were begun, and it was seen that it would be necessary to withdraw and hold permanently many of the forested areas above the reservoirs at the sources of the rivers. At all times there has been close co-operation between the Engineers engaged in studies of water supply and the men investigating the forest reserves.

Upon the passage of the Reclamation Act of June 17, 1902, and the organization of the Reclamation Service as a part of the Geological Survey, the question of the extent and preservation of forest reserves assumed increased importance. The scientific investigations of water supply were supplemented by authority to build great works, and there followed the necessity of protecting these works by every available natural resource. These great works might be seriously injured if individuals were permitted to come in above them and secure vested rights inimical to the larger irrigation interests of the country; therefore the Reclamation Service has asked that large areas of public land embracing forests or woodlands be withdrawn and held permanently, so that there might be no interference with the larger development of the waters.

In mapping the forest reserves and in recommending their boundaries all the large matters of this character have been taken into consideration. Frequently an individual, looking at the matter from his standpoint, is inclined to criticise the drawing of boundaries and to assert that too much land has been included; but if he would study the problem from the community or public standpoint he would find that this land is of great importance in connection with the control of the water upply necessary to the development of a reclamation project.

By carefully and systematically permitting the younger growth to accumulate, and perhaps by seeding the steeper barren slopes, it will be possible to reduce the destructive effects of the so-called cloudbursts or local storms which wash the loose soil into the reservoirs or clog the hydraulic works. The beneficial effect of this protection is well understood and every reasonable effort is being made to bring about the best possible conditions in the catchment basins of the streams.

* * * *

The miner has a great and vital interest in the permanent preservation of the forests and in their intelligent utilization, second only to that of the irrigation farmer. He should be one of the strongest supporters of the Government in its attempt to preserve our woodlands and make them useful to all interests.

* * * *

II.

A Federal Forest Service, by Gifford Pinchot, Forester, U. S. Department of Agriculture.

* * * * *

The Forest Service is charged with the protection and administration of the national forests. These forests at present cover an area of rather more than 63,000,000 acres, and are slowly increasing. They lie almost entirely upon high land at the headwaters of streams in the Western States and Territories, and are of vast importance to the irrigation and grazing interests, as well as to the users of wood. They are the key to the prosperity of the West.

* * * * *

III.

The value of Forestry to Commercial Interests, by George H. Maxwell, Executive Chairman, the National Irrigation Association.

* * * * *

But it is not enough merely to repeal the Timber and Stone Act. Every acre of public forest lands or brush or wood lands which conserve a water supply should be at once embraced in permanent forest reserves, the title to be always retained by the national Government, and the stumpage only of matured timber to be sold.

The whole great plains region should be studied and developed as a vast area which can be transformed from a semi-arid region to one of great fertility and more humid climate by the planting of immense areas, hundreds of thousands of acres, of new forests by the national Government on the wide level prairies and bare, rolling foot-hills which are now supposed to be among the waste places of the land and only fit for grazing ground for a few stray cattle and sheep.

It is the vast possibilities of forest planting and timber production in this region that makes it almost a crime against future generations to part with the land in its present condition to stockmen under such a scheme as the Kinkaid bill for the creation of large grazing estates in private ownership.

The mining and transportation interests, more immediately than any other, ought to oppose this 640-acre homestead idea anywhere in the great plains or Rocky Mountain States, and help to inaugurate a great national policy of planting new forests, not only to furnish wood and timber for the mines, and railroad ties and timber for railroad construction and repair, but to conserve and increase the rainfall, regulate the flow of the rivers, stop floods and furnish water for irrigation.

* * * *

Let us carry the picture in our minds a little farther up the river and look at Kansas City and that great flood that came so near destroying its business section that same winter. Look at the Ohio River flood in the Pittsburg vicinity that same winter. Look at the Allegheny mountain region a year later. I came down from Harrisburg to Washington last spring when Congress was in session. The railroad tract had been submerged and torn to pieces in many places by the flood and the ice was banked up as high as the second storey windows of the farmhouses to the left as we came down the river.

It is only within the last two weeks that I read an article in the New York papers to the effect that cities of that Allegheny region were without water, the railroads were hauling water and the mines were shut down because the rivers were dry.

I ask, why is that? And I will answer the question for you. It is because we have gone over those hills and mountains with axe and fire and stripped the hillside and the mountain tops of the whole Allegheny region, and instead of having a natural forest cover, which is the greatest reservoir known to nature or to man, we have a surface which sheds water as fast as the floor of this hall would shed it if you stood it at an angle of 45 degree.

* * * * *

IV.

Will the administration of the Forest Reserves on a conservative basis retard the development of Mining? by Seth Bullock, Supervisor, Black Hills Forest Reserve.

* * * * *

Another important factor in the business of mining as conducted in the Black Hills, fully as essential as timber, is an ample supply of water; for if this is insufficient, the separation of the values from the mined ore would be impossible and the labour and expense of mining lost. As it is necessary, owing to these low grade ores, that the stamp mills or reduction works be placed as near the mine as possible, large sums of money have been expended in supplying these plants with water which is derived from mountain streams, the continuous flow of which is dependent upon the preservation and maintenance of the forest conditions at their source, the fact being now unquestioned that the denudation of the timber and forest cover, and the removal of vegetation at the supply points of our mountain streams, seriously check their flow and will in time cause their disappearance.

* * * *

V.

The general need of Forest Preservation, by James Wilson, Secretary of Agriculture and President of the American Forest Congress.

* * * * *

I am glad to see the irrigation interests so strongly represented here, because forestry and irrigation go hand in hand in the agricultural development of the West. The West must have water, and that in a sure and permanent supply. Unless the forests at the head-waters of the streams used in irrigation are protected, that is impossible, and irrigation will fail. Unless we practise forestry in the mountain forests of the West, the expenditure under the national irrigation law will be fruitless, and the wise policy of the Government in the agricultural development of the arid regions will utterly fail. Without forestry, national irrigation will be merely a national mistake. The relation in the arid regions between the area under forest and the area in farms will always be constant. We can maintain the present water supply of the West by the protection of existing forests. In exactly the same way, we can increase this supply by the foresting of denuded watersheds. The full development of the irrigation policy requires more than the protection of existing forests—it demands their extension also.

* * * * *

VI.

Importance of the Forests to Agriculture, by Hon. John Lamb, Member of Congress from Virginia.

* * * * *

It is claimed that about two hundred square miles of fertile soil are washed into the rivers annually in the United States, while the loss in crops and other property destroyed by floods will run up into the millions.

The most of this loss can be traced to the destruction of the forests along the iver banks.

* * * * *

VII.

The close relation between Forestry and Irrigation, by Guy Elliot Mitchell, Secretary, the National Irrigation Association.

The connection between a comprehensive system of forestry and irrigation is a somewhat local though vital one, directly affecting as it does but one-half of the territory of the United States—the arid region.

* * * * *

In the western half of the United States the destruction of forests has an intimate, immediate bearing upon the capacity of the States to sustain population, for population results from irrigation; irrigation depends upon water supply, and the water supply is the melting snows caught and held by the forests clothing the great mountain chains of the Sierras and the Rockies—nature's great storage reservoirs.

Three things are necessary to ensure a maximum water supply for irrigation:

First, prevent wholesale destruction of timbered watersheds.

Second, substitute therefor a rational system of timber cutting; and,

Third, reforest and afforest lands where the value of the increased water supply will warrant this most advanced and expensive feature of the American forest plan.

* * * * *

In many parts of California the whole future welfare of the State depends upon the way in which you are able to use your water supply; and the preservation of the forest and the preservation of the use of the water are inseparably connected. Whatever tends to destroy the water supply of the Sacramento, the San Gabriel, and the other valleys strikes vitally at the welfare of California.

* * * * *

VIII.

Forest and Reservoirs, by F. H. Newell, Chief Engineer, United States Reclamation Service.

All are aware that the Government, through the operation of the Reclamation Act of June 17, 1902, is building large irrigation works throughout the West. The fund for that purpose now amounts to about $25,000,000. These works, national in character, are being constructed as rapidly as possible. The protection of these works, their future use, their stability through all time, is largely dependent upon the proper treatment of the forests upon the mountains above the reservoirs. In fact there is hardly a project now under consideration whose future success is not closely joined with the questions of the best use and preservation of the forests and to a less degree of the grazing land immediately adjacent. These works are being built to last for all time, and if they are to be preserved in their best condition, it must be after we have solved this question of the best protection and use of the forest.

* * * * *

IX.

Forest areas, catchment basins (*impromptu* address), by H. M. Wilson, United States Geological Survey.

I am very much interested in one feature of the discussion that has been brought before you to-day, and that is the relation of run-off from catchment basins to the forested areas of those basins. There is nothing new on this subject, however, which it seems to me I can bring before you. I heartily concur in the general opinion expressed by two of the speakers, Messrs. Lippincott and Davis, upon the effect of forests in regulating the discharge of streams and thus adding to their usefulness as providers of water for irrigation and upon the effect of this regulation in preventing disastrous flood which, by eroding the surface of the soil carry vast amount of sediment to the stream below and destroy both them and the surfaces which they erode.

* * * * *

APPENDIX III.

The 8th International Congress of Agriculture is to be held at Vienna on the 21st—25th May 1907 at which representatives from all European countries and from America will be present. The Austrian Minister for Agriculture will be the Honorary President and the Vice-President of the Austrian "Chambre des Seigneurs," acting President. The representatives include scientists and men of note on the committees and as members of each section.

There are eleven sections sub-divided into groups, and in five of these sections Agriculture is considered in its intimate connection with forestry.

Section II—is devoted to the consideration of education in agriculture and forestry.

Section V—deals with improvements in agriculture and forestry, in particular with irrigation and drainage of soils, of the regulation of the water supply, of agricultural operations and of protection against torrents and avalanches.

Section VI—considers those industries dependent on agriculture and on forests.

Section VII—is devoted to the protection of plants and fruit and forest trees, and

Section VIII—takes up forest management and utilization.

It is unnecessary here to enter into further detail of the groups into which these main sections are divided. This appendix is added merely to show that at the present day every European country is convinced of the intimate connection between agriculture and forestry and that they avail themselves of the opportunity of ascertaining the progress that has been made elsewhere in investigation and knowledge of these two important sciences.

G. I. C. P. O.—No. 724 R. & A.—10-11-06—700—W. J. D.

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Forest Bulletin No. 10. 1907.

A NOTE

ON

THE DUKI FIG-TREE BORER OF BALUCHISTAN.

(BATOCERA RUBUS.)

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.,
Imperial Forest Zoologist to the Government of India.

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A NOTE

ON

THE DUKI FIG-TREE BORER OF BALUCHISTAN.

(BATOCERA RUBUS.)

Introduction.

IN January of the present year (1906), I received a communication from Major C. A. Kemball, Political Agent, Loralai Agency, Baluchistan, to the effect that the fig trees in the Duki garden were suffering from a boring pest. This garden is situated in the Duki sub-division of the Agency, and, as is the usual custom in the Baluchistan Agencies, is kept up by the Political Agent with the object of supplying plants, shade trees and fruit trees, etc., to the villagers of the country. In other words to encourage arboriculture and fruit culture ; the former a great desideratum in a sandy desert country, the latter as a source of revenue.

The Political Agent wrote that the fig trees in the Duki garden were very fine ones and formed the main source of income from the garden. Some willows in the garden were also infested by boring grubs, and it was feared that both trees were being attacked by the now well-known and justly-dreaded Quetta borer (*Æolesthes sartus*). This fear has however been laid to rest as a result of the energetic and successful action of Major Kemball, who was successful in procuring specimens of the beetle from the attacked trees in the summer months—a most highly creditable and valuable piece of economic scientific work.

Previous Reports of the Pest.

Major Kemball has informed me that the borer was first observed in a tree at Duki by Mr. Turner, Extra-Assistant Commissioner of Duki, in May or June 1905. Later on in December 1905 it was found that all the fig trees in the garden had been attacked.

Whilst at Fort Sandeman towards the end of November 1905, on my return from a visit to the Chilgoza Forests of Zhob, Major Roome, Commandant of the Zhob Levy Corps, informed me that the fig trees in the Levy Corps garden at that place were attacked by some borer resembling the Quetta borer. I inspected these trees in company with Colonel Chevenix-Trench and Major Roome, and we cut out of them some long apparently full-grown longicorn grubs greatly resembling those attacking the poplars and willows, etc., in Quetta. I at the time expressed the opinion, however, that it was improbable that there was any connection between the two insects.

From an examination of fig trees in the Loralai Cantonment garden Major Kemball is of opinion that they have been attacked in years gone by by this pest. The garden *mali* states that the trees were once infested but that the insects subsequently disappeared. His information is said, however, to be very vague ; as is usually the case with natives when questioned on such matters.

In a subsequent communication dated 13th November 1906, Major Kemball wrote that the Extra-Assistant Commissioner had reported that the fig trees in the Barkhan garden situated about 100 miles from Duki had been attacked by a borer which was first noticed on the 8th October 1906. An examination of the grubs has shown that the insect is the same as that present in the fig trees at Duki and Fort Sandeman.

Distribution.

Up to the time of writing I have only received reports of the presence of this pest in the Duki, Barkhan and Fort Sandeman gardens.

Major Kemball thinks, however, that it will be found to be more widely spread in the Loralai Agency, and personally I am of opinion that the insect will probably be found throughout Baluchistan. This however requires confirmation.

Description of Grub and Beetle.

Only the larva and the beetle have as yet been obtained.

Larva or grub.—The full grown larva is a long, thick, tuberculate, yellowish grub, 3¾ inches in length and three-quarters of an inch broad at the anterior end, which is thickest. The head is black, broadest behind, and bluntly-pointed in front, the two biting jaws (mandibles) being black. The segment following the head is broad and swollen, dark orange-yellow, the upper surface being hard and horny and shining; the two following segments are narrow; the remainder are slightly narrower than the first, thick, with swollen tubercles on each; the last two taper bluntly. There are a pair of minute feet on each of the first three segments and a pair of swollen tuberculate ones on the fourth to the ninth segments. A transversely elongate brown spot (the breathing opening or spiracle) is situated on each side of the second and the fourth to the eleventh segments. Pl I, fig. *a* shows a larva two-thirds grown and fig. *b* a full-grown grub.

Beetle.—A large stout insect with long antennæ and legs. Black or ferruginous yellow, dull, with a series of dirty yellowish spots on the elytra. Head set vertically on thorax with the jaws, which are long and powerful, at the lowest end. Antennæ black; a row of sharp small teeth on inner edge of the third joint. Thorax transversely ridged on the anterior and posterior edges with irregular ridges and wavy lines on the intermediate portion. At the sides the thorax is produced medianly into a sharp pointed tooth. Four orange spots are placed circularly on the dorsal median area. Elytra (wing cases) truncate at the base with well marked shoulders which end in small sharp teeth; they are constricted and rounded at the apical end. The basal quarter is studded with small shining rather scattered projecting elevations which are largest at the base and decrease in size anteriorly. Rest of surface smooth. Two irregular longitudinal lines of yellow spots, 17 or less in number, on each elytra. In some specimens these spots form a well defined line near the apex of the elytra.[*] The last segment of the body is left exposed by the elytra. Under surface black, shining, with a broad lateral white stripe running down each side. Legs ferruginous black.

---

[*] This insect was kindly identified for me by Mr. C. O. Waterhouse of the British Museum. In his letter Mr. Waterhouse wrote, "The specimen sent, however, has a line of spots near the apex of the elytra which is unusual, and it would be worth while to notice if your others have this." Plate I, figs. *f* to *i* show several elytra in which the position and number of the yellow spots vary considerably. Those depicted on the left have as many as 17 spots, whilst the ones on the left have 9 only and the intermediate ones 14 and 15 respectively. These beetles were all taken from the infested trees at Duki.

The male is distinguished from the female by having the antennæ longer than the total length of the insect. In the female the antennæ do not reach to the apex of the elytra; length 2-2¼ inches. Figs. *c, d* depict a side and dorsal view of the female beetle, and fig. *e* the head of the male beetle.

Life History.

The beetle commences to issue from the trees about the middle of June, and is found throughout the remainder of the month and on through July. It is apparently most plentiful in July. This period of six to seven weeks then is the egg-laying period. The eggs have not yet been discovered, but they are probably laid either singly or in little clusters on the outside of the bark of the tree or in incisions made by the beetle in the outer bark so as to reach the softer parts beneath. The number of eggs laid is at present unknown.

The grubs on hatching from the eggs in July or August feed at first in the green sappy portion of the inner bark, and then, as they become larger and stronger, tunnel down into the wood and bore down the centre of the stem or branch in a direction parallel to the longitudinal axis, mining out a gallery which increases in breadth with the growth of the larva (see Pl. II). If the grub commences in a branch, it tunnels down the branch until it reaches the main stem and then tunnels down that. The tunnel is blocked behind by the excreta of the larva, the portion occupied by the latter being full of sap. As it progresses down the stem or branch it eats out at intervals longitudinal offshoots to the outer bark, these longitudinal tunnels being aëration tunnels serving to admit air into the stem. The sap oozing from these is an indication that a grub is at work inside the stem. The larger branches and the main stem of the fig tree, including the bottom portion of the stem and the upper thick portion (the crown) of the roots, are the parts of the tree infested by the grub, the galleries eaten out by the mature larva being as much as one and a quarter inches in width (see Pl. II, *c*) and a foot or more in length.

When full fed the grub pupates in the heart of the stem or upper part of the root, eating out a wide elliptical pupal chamber which it blocks at the open end with a mass of compressed wood fibres, some loose wood fibres occupying the lower end (see Pl. II, *d*).

The pupa spends 3 to 3½ months in this stage. The beetle, when mature, bores a circular tunnel straight to the outside of the tree, the large exit hole being very visible on the outside (see Pl. II, *f*).

Damage committed by the Insect.

Up to the present it has not been definitely proved that this pest kills the fig trees. Major Roome informed me that some of his trees in the Zhob Levy Corps garden at Fort Sandeman were so badly riddled that one or two were blown down and several others had to be cut out. I myself saw two or three trees in this garden which were so full of larvæ that it appeared to be only a question of time when they would succumb to the attacks of the insect. Major Kemball informs me that no trees have so far actually died under the attacks at Duki. It would seem, however, that in this garden the attack has only recently culminated in its at present undoubtedly serious condition. The insect, occurring but sparingly at first, committed but small depredations and these remained unnoticed.

We have seen that the grub tunnels chiefly inside the stem and branches of the trees; it is owing to this method of attack, whereby the bast layer (the layer up which the sap passes and therefore the layer upon which the life of the tree depends) remains for the most part untouched, that the trees are not at once killed by the insect. At the same time the strength of a tree containing many boring larvæ is naturally sapped and undermined owing to the numerous hollow galleries and tunnels it contains. It therefore becomes but a question of time for the tree to succumb to these attacks; either being blown down by the wind, or falling owing to the stem being no longer capable of bearing the excessive weight of the crown.

It should also be remembered that these trees are in themselves a danger, since by rearing up larvæ which become beetles and lay eggs they help to spread the infection to as yet unattacked or but slightly attacked trees. The beetles also, owing to their power of strong flight, are able to carry the infection to unaffected gardens and trees.

Major Kemball's energetic action in procuring specimens of the beetle has set at rest the fear that the willow and fig tree borers at Duki are one and the same insect, a fact which would have proved of serious importance. The willow borer is a grub belonging to quite a different family of beetles, the *Buprestidæ*, and feeds in a different way. Neither has any connection, as I have already pointed out, with the Quetta borer.

Protection and Remedies.

From what has been written above the question of the protection of the fig trees and of infested gardens becomes a matter of considerable importance.

Undoubtedly the question which first presents itself for consideration is the distribution of this pest. In this connection I would most strongly recommend that every garden containing fig trees in Baluchistan should be most carefully inspected and search made with the object of ascertaining whether the grubs are present or not. It will be of little use, as Major Kemball has rightly pointed out, clearing one garden of the insect if others in the neighbourhood remain untended. It is hoped that this note will be an aid to accomplishing this necessary work.

We come now to the question of the infested gardens. It has been shown that from the nature of the attack on the tree the latter will not necessarily die owing to the presence in it of the boring grubs. Only in the event of their being very numerous in it will a tree be likely to succumb to the attack. At the same time we must remember that every infested tree is a source of danger to others as well as to itself, since the presence of a few larvæ only in a garden or in a single tree means the future appearance of beetles who will give rise to a progeny greater in numbers than themselves, and will result, in the course of time, in a serious infestation.

My recommendations are, therefore, as follows:—

1. Where a tree is seen to be very seriously infested by the pest and to contain, from the evidence of numerous external holes, a large number of larvæ, that tree should be cut out, cut up into billets and burnt. Particular attention should be taken to ascertain that every portion of the wood is well charred.

The period of cutting and burning should be between the end of October and the end of March.

2. Where a tree is not seriously infested the branches, or portions of the main stem if high up, should be pruned off and burnt, as detailed above. In both cases they should be pruned off below where the insect is seen to be at work and the pruned spot should be thickly coated with tar.

3. From the beginning of June to the end of August the parts of trees infested with grubs should be enveloped in muslin (mosquito-netting) bags, tied above and below the area containing the grub. These bags should be inspected daily and all beetles issuing from the areas so enveloped, who will be unable to escape owing to the netting, should be killed. Crushing them against the stem of the tree without detaching the netting, will be sufficient. The daily inspection is necessary, otherwise male and female beetles may issue in the same bag, pair, and the female may lay eggs on the confined area before she is killed. Should this take place the work and supervision entailed will be of no avail, since the eggs will hatch into grubs and these latter will carry on the attack in the tree. It was by means of such bags that Major Kemball had the beetles caught which set at rest the question of the identity of this pest.

4. Between the dates specified in the preceding paragraph a careful inspection should be kept in the garden for beetles issuing from parts of trees unprotected by the bags and all such found should be caught and killed. This inspection should be made in the day time and at night with a lantern. The beetles will usually be found clinging to the bark of the trees.

5. If the above recommendations are carried out with care it is probable that a couple of years should be sufficient to almost entirely clear a garden of this pest.

Points in the Life History of the Pest requiring further Observation.

There are still some further points in connection with the life history of the insect to be ascertained :—

(1) Where the eggs are laid and the number laid by each beetle.

(2) The length of time spent in the grub stage. Is it more than one year?

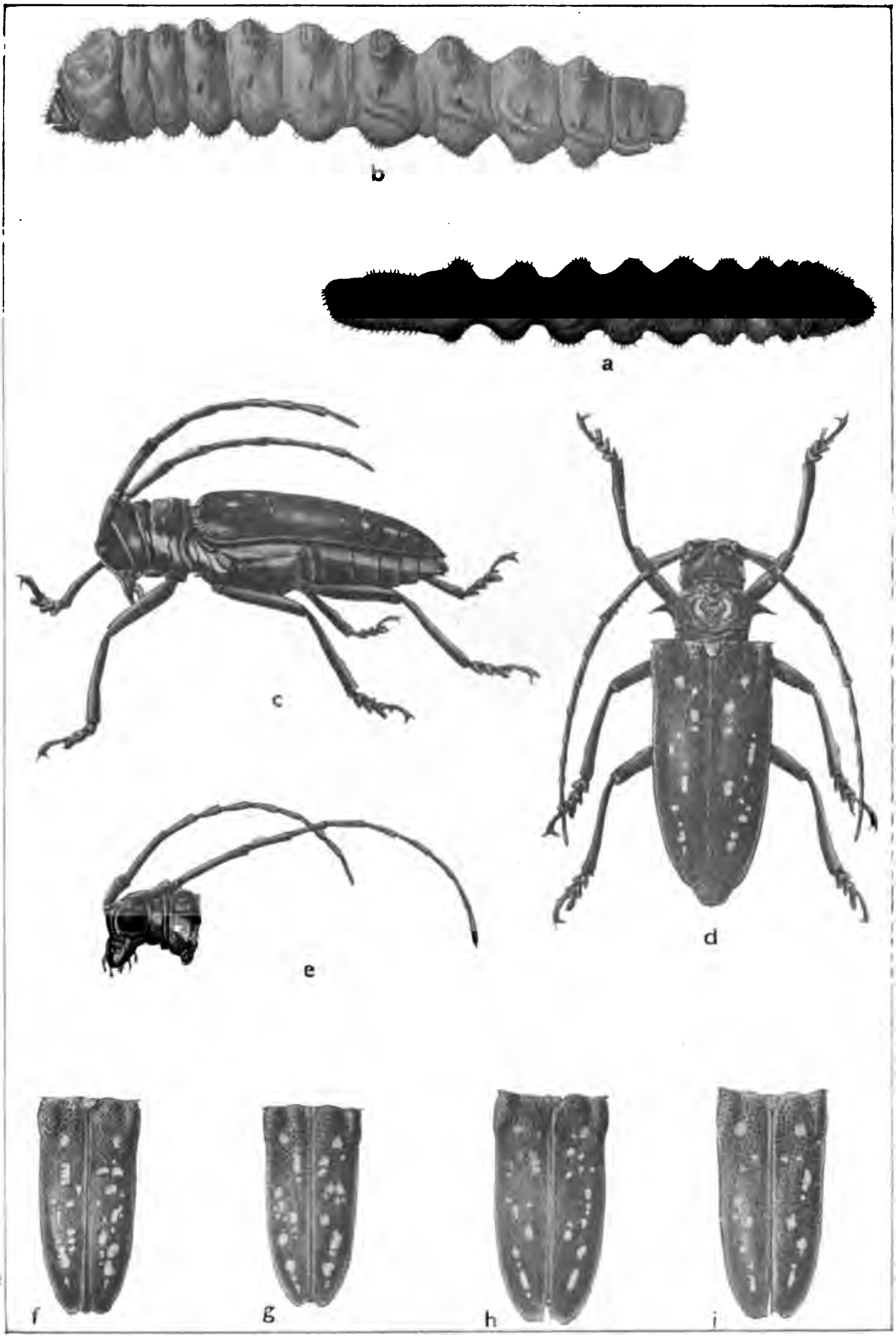
(3) The length of time spent in the pupal or chrysalis stage. Since full grown grubs have been taken in February and beetles in June this is probably only about four months.

(4) Whether the borer attacks other trees besides the fig tree. We have seen that the borers infesting the willow trees at Duki belong to a different species (and family) of beetles.

G. I. C. P. O.—No. 1404 I. G. For. -11-4-1907.—600.—J. J. M.

PLATE I.

a.—Larva two-thirds grown.
b.—Larva full grown.
c. d.—Side and dorsal views of female beetle.
e.—Head of the male beetle showing the elongate antennæ.
f. to *i.*—Elytra showing the variation in the yellow markings.



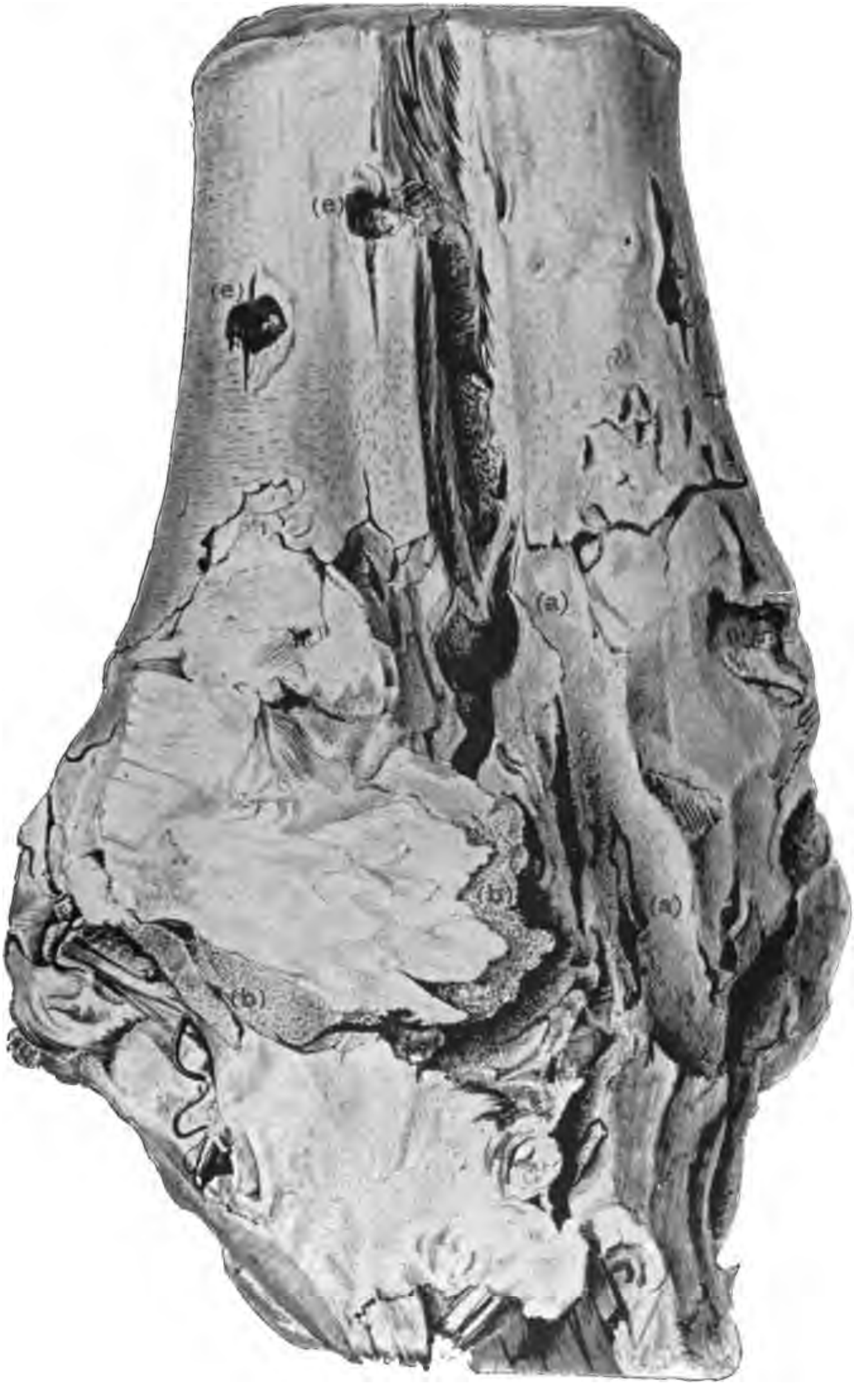
S. B. Mondul, del.

The Duki Fig-Tree Borer.

(Batocera Rubus.)

PLATE II.

Section of the crown of the root and base of the stem of a fig tree showing the shallow galleries (*a*) made by the grubs feeding in the bast layer of the inner bark and the wood blocked in places by wood excreta (*b*); (*c*) the deeper tunnels made in interior of tree by older grubs with pupating chamber at (*d*); (*e*) aëration hole; (*f*) exit hole of beetle from tree.



S. B. Mondul, del.

Attacks of the Duki Fig-Tree Borer
in the lower part of the stem of a Fig-tree.

Photo.-Mechl. Dept., Thomason College Roorkee.

est Bulletin No. 11 1907.

ON

SOME ASSAM SAL (SHOREA ROBUSTA) INSECT PESTS.

WITH NOTES UPON SOME INSECTS PREDACEOUS AND PARASITIC UPON THEM.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.,
Imperial Forest Zoologist to the Government of India.

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Correction Slip to the monograph on Some Assam " Sal Insect Pests."

Owing to the Author's absence in England on furlough some small inaccuracies crept into Plate VI necessitating the following corrections in the context and in the description of the plate.

Corrections.

Page 24, line 18.—For "figs. 5, 5*a* 5*b* show larva pupa and beetle" *read* " figs. 5, 5*a* show male and female beetles and enlarged antenna of female."

Page 24, line 37.—After " length " *insert* " fig. 5*e*."

Page 25, line 13.—After " One side " *insert* " fig 5*b*."

Page 29, line 22.—For " See Pl. V, fig. 6 " *read* " Pl. V, fig. 6 shows the beetle."

Correction to Plate V.

For " FIG. 5.—Larva of ...." to " galleries made in green sal Wood."

Read " FIG. 5.—Sphærotrypes assamensis, n. sp. male.

5*a*. " " female and enlarged antenna.

5*b*. Pairing chamber in sap wood of a branch.

5*c*. " " bark of main stem.

5*d*. Egg and larval galleries made in a green sal tree. This shows the small bent unfinished egg-gallery made by the female in the sap wood which is full of sap; the larval galleries are also very much smaller than the normal.

5*e*. Normal egg and larval galleries made by this species."

G. I. C. P. O.—No. 996 R. & A.—18-11-1907.—600.—B. N. D.

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Forest Bulletin No. 11 1907.

ON

SOME ASSAM SAL (SHOREA ROBUSTA) INSECT PESTS.

WITH NOTES UPON SOME INSECTS PREDACEOUS AND PARASITIC UPON THEM.

BY

E. P. STEBBING, F.L.S., F.Z.S., F.E.S.,
Imperial Forest Zoologist to the Government of India.

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CHAPTER I.

I.—INSECTS INFESTING THE BAST LAYER AND WOOD OF THE ROOT, MAIN STEM, AND LARGER BRANCHES.

1. HOPLOCERAMBYX SPINICORNIS, Newn.

(The Singhbhum Sal-Borer.)

Order—**Coleoptera.** Family—**Cerambycidæ.**

References.—Steb. Injurious Insects of Indian Forests, p. 71 (1899). Calcutta.
Steb. Note on The Life History of Hoplocerambyx spinicornis, Forest Bulletin No. 8 (1906). Calcutta.

Nature of Attack.

The grub feeds in and destroys the bast layer and sap wood of the tree, subsequently tunnelling right down into the heart-wood to pupate. The tree is killed by this pest, and its timber is also destroyed.

Previous Records of the Insect.

In a note on *The Life History of Hoplocerambyx spinicornis*, the Singbhum Sal-borer, I have described the damage done to the Sal tree in the Central Provinces and Chota Nagpur by this pest, probably one of the most dangerous at present known to infest the Sal belt of that part of India. Recent investigations have now shown that the insect is equally plentiful in the Sal Forests of Goalpara, Bhutan, and the Buxar Duars, and it is probably an inhabitant of the whole of Sal tract in this part of the country. It was reported from the Apalchand Range, Jalpaiguri Division, west of the Buxa Duars, in November 1905. Systematic study has shown, however, that although the damage committed is of a similar character to and quite as serious as that occurring in the Central Provinces, its life history in Assam has certain important differences from the one already described in the note above alluded to. These differences, it would appear, are chiefly, if not entirely, due to the hotter, or rather damper, climate of the tract the insect here inhabits.

Description.

It will be unnecessary to describe here any of the stages of the metamorphosis of the insect save that of the egg. Larva, pupa, and beetle have been fully described in the note already published. I may here allude, however, to the extraordinary variation in size of this beetle. From measurements made from a large number of specimens I find the male beetle ranges in size from $1\frac{1}{16}$ inch to $2\frac{11}{16}$ inches, whilst the female varies from 1 inch to $2\frac{1}{8}$ inches.

The following is the description of a freshly laid egg:—

Egg.—Elongate, cylindrical, slightly swollen at the anterior end; white, opaque, shining, with blunt rounded ends. Length $\frac{1}{8}$ inch. (See Pl. I, Fig. 1.) The egg-shell is white and of a papery-like consistence (Fig. 1*b*).

Young larva.—The newly hatched grub is about $\frac{1}{8}$ inch in length, yellow, shining, thickest anteriorly. (See Fig. 1*c*.)

Life History.

Appearance of beetle on the wing.

This beetle was exceedingly plentiful in the Kachugaon Forests of the Goalpara Division in the latter half of May. Mr. Perrée is of opinion that it first begins to appear towards the end of March or beginning of April. It is present in the forests all through June, but begins to get scarce in July as proved by the observations made by Rama Nath Mukerjee after my departure from Goalpara at the end of May. He kept some countings by felling trees to attract the beetles. I shall allude to these later on.

I cannot at present say whether this insect is again found on the wing in Assam later on in the year, but I think it is just possible that it may appear again in September-October. Immature specimens of the beetle were taken from the pupal chambers in green standing trees in the Apalchand Range, Jalpaiguri Division, in November.

Instinct of beetle.

The beetles are gifted with an instinct which enables them to seek out unerringly newly felled or standing trees in the forest in the condition they require for oviposition. This can easily be proved by felling a green tree in the forest. One such felled on the 13th May was inspected next morning and a large number of both male and female beetles were found on the lower side of the bark between the trunk and the ground.

Pairing and egg-laying.

Position where eggs are laid.

The male seeks the female in such places and pairs with her on the bark of the tree. It has been noted that the insects vary very greatly in size, but this fact appears to be immaterial in the pairing of individuals, a small male pairing with a large female or *vice versâ*. Opportunities occurred of watching the insects in coitû and the procedure is rather curious. The male insect mounts on to the back of the female and oviposition alternates with the act of fertilisation. The penis of the male is hard, and horny, very long and curved scimitar-shaped backwards and downwards. The actual act of pairing appears short. The female possessess a long flat bluntly-pointed, tapering, telescopic ovipositor about ½ inch in length and brown in colour. With this she deposits her eggs here and there in crevices in the bark or on the flakes of bark. The ovipositor is very flexible and is used to grope about and search out suitable places for oviposition just as an elephant uses its trunk. The eggs, which evidently develop very rapidly in the ovisac, are laid singly and are scattered about in a most erratic manner. The female appears to choose preferably moist sappy areas of bark on the lower sides and underside of the fallen trees or on the shady side of standing ones; but eggs are also to be found in dry crevices and on the outer surface of dry bark or amongst short wet moss on the bark. They are found most numerously, however, in the moist bark areas. She will also deposit them on the upper surface of the bark of felled stems and on the sunny side of standing trees in dull weather, and very little attention appears to be paid to the actual site chosen for deposition. I have even found them forced down the entrance holes of the *Sphærotrypes* bark-boring beetle in the bark. Pairs in coitû were watched. The female walked slowly over the bark laying an egg here and there at intervals, and in the intervals the insects paired. It was thought that the beetles commonly laid eggs in the sleepers or on barked logs, but although young larvæ have been found in both, I do not think it has been yet proved that, as a general rule, the eggs from which they hatched had not been previously laid in bark which was subsequently removed. Mr. Rama Nath Mukerjee took this year (June) some eggs on newly converted green sleepers, and I myself found some small larvæ two weeks or so old in logs recently brought out to the tramway.

Number of eggs laid.

I have not yet been able to ascertain the number of eggs laid by a female. Some countings were, however, made to ascertain the number of eggs laid on a tree. On a 15-foot strip of bark taken round the whole circumference of a newly felled tree 150 eggs were laid between the night of 14th—15th May and the 19th of the month, or 6,000 eggs on a 55-foot bole.

Number of beetles laying in trees.

Eggs were laid subsequently to this date. From this tree, which was felled on the 14th, 54 beetles were taken on the 16th and 40 beetles on the 19th.

Mr. Rama Nath Mukerjee kindly carried on these observations until the 17th July, and has submitted the following interesting note :—

Period at which beetles begin to disappear from forest.

Result of inspection of Sal trees felled for the purpose of determining what periods of the year the longicorn beetles are to be found on the wing.

Sal tree No. 3.—Green, blown down by storm on the 29th May 1906. Girth 5 feet 4 inches. Length 50 feet. Forked at a height of 21 feet, stem full of knots, all the roots (except few small side ones) were found to have been attacked by fungi. There was no other external sign of disease. Specimen of roots collected.

30th May 1906. Beetles found	606	at 7 A.M.=207 „ 10 A.M.=189 „ 4 P.M.=210
Some eggs were found on the stem.		
31st May 1906. Beetles found		19
1st June „ „ „		7
3rd June 1906. The eggs collected on the 30th May 1906 were found to have hatched in the tube.		
4th June 1906. Beetles found		15
Total beetles found on tree No 3		647

Sal tree No. 4.—Green, felled 8th June 1906. Girth 4 feet 3 inches. Length 61 feet.

9th June 1906. Beetles found	228
10th „ „ „ „	24
13th „ „ „ „	9
Total	261

Sal tree No. 5.—Green, felled 20th June 1906. Girth 4 feet 5 inches. Length 61 feet.

21st June 1906.	Beetles found	128
22nd ,, ,,	,, ,,	47
23rd ,, ,,	,, ,,	21
25th ,, ,,	,, ,,	20
26th ,, ,,	,, ,,	9
9th July ,,	,, ,,	8
	Total	233

Sal tree No. 6.—Green, felled 8th July 1906. Girth 4 feet 3 inches. Length 72 feet.

9th July 1906.	No beetles were found.	
10th ,, ,,	,, ,, ,, ,,	
16th ,, ,,	,, ,, ,, ,,	
17th ,, ,,	Beetles found	3

In November 1905, Ranger Rakhal Das Chakravarti reported that he had discovered longicorn grubs tunnelling into living Sal trees, "trees of 5 feet in girth having completely succumbed on account of their attack." These grubs were collected on November 6th. A fortnight later the Ranger took some immature living beetles from the same locality. They proved to be *H. spinicornis*.

Trees chosen for egg-laying.

The beetles invariably choose newly felled or green sickly standing trees in the forest for egg-laying. An inspection of some large trees felled in February last and still lying unbarked in the forest showed that no fresh eggs had been laid on the bark although the sap wood contained young larvæ. Trees which are being suppressed or slowly strangled by heavy creeper growth are apparently often chosen for egg-laying purposes.

Habits of beetle.

The beetles fly at night. In the day time they hide either beneath the bark of newly felled trees, large numbers being invariably found here in the last fortnight of May 1906, or in the under-growth in the forest. More rarely they are found in interstices of the bark of standing trees, their colouration approaching that of the Sal bark. They are powerful fliers and probably travel a considerable distance in search of suitable trees. During a heavy storm one night considerable numbers were blown from the forest about four miles distant into the verandah and rooms of the Kachugaon Bungalow, and in this way they probably get dispersed over considerable areas. The incident proved that the beetles are sufficiently powerful to fly at night in heavy wind and rain.

Hatching out of the grubs.

The small grubs hatch out from the eggs within 5—8 days after oviposition. In hatching the egg-shell splits longitudinally down one side. The newly hatched grub is about ⅛ of an inch in length. A green tree free from the insect was felled on the 13th. It was at once attacked (on the night of 13th—14th) by the beetles, and on the 23rd was full of young larvæ a few days old whilst others were just hatching out. The largest found was ¼ inch in length and probably 4—5 days old (Fig. 1*d*). This larva was taken from the gallery shown in Fig. 1*f*. Others are shown in Fig. 1*e*. Unlike the larva of many longicorn grubs this one does not spend any time feeding in the bark, but at once bores straight down through it to the sap wood and commences to bore an irregular shallow gallery in this latter. This gallery is at first narrow and consists of two or more arms (Fig. 1*e*). It is entirely packed with the wood excreta ejected by the larva, the only free space in it being the one occupied by the body of the grub.

Life history of larva.

The larva spends its whole life feeding in the wood, remaining in the sap wood until it has attained full growth. It is to be found in the larger roots, main stems, and in the larger branches of the crown of the tree. It bores large, irregular galleries here which are invariably blocked with wood refuse. In these operations the cambium layer is usually completely destroyed. The grub has evidently a very rapid growth when in favourable situations as regards food supply. This is proved by the fact that larvæ evidently hatched out during the present year were found over an inch in length. In this respect I am of opinion that the life history of the insect differs from that passed through in the drier climate of the Central Provinces. I have shown that there the larva takes about 18 months to reach full size and pupate. Here in the damp heat of the Assam climate 8—9 months would appear to be the maximum time usually passed by the larva in this stage of its existence. Its work in the tree, performed at a greater rate, is of a similar nature to that of its confrère in the Central Provinces, and it pupates in the same way by boring down into the heart-wood and eating out a pupal chamber in the long axis of the tree.

I came across several instances of trees, felled in February 1906, which contained larvæ at least half grown in the latter half of May. The explanation is to be found in either of the two following suppositions :—

(*a*) The beetles appear more than once in the year, winged beetles making their appearance in the autumn months although there is no true second generation, the insect taking a year to pass from egg to beetle.

(*b*) The grubs spend the cold weather as such in a dormant condition in the pupal chamber in the heart of the tree, the period of feeding being in the one case from March to about November by which time they are full grown, in the other from June to March and March to June when they would pupate. As a matter of fact larvæ were found in the heart of logs or on their way there in the latter half of May. These could scarcely have matured and issued as beetles by the end of June or first week of July, and therefore they may issue later in the year.

Plates II and III show the work of the grubs in the sap wood and some larvæ and beetles in the pupal chambers. The curious white calcareous coverings made by the larva so as to close the pupal chamber against the attacks of predaceous foes are also well shown in this plate. The illustrations are from photographs of a tree felled in the forest in February 1906 ; both boring grubs and one or two beetles just ready to emerge were found in it. Also some pupæ taken from the wood in April 1906. To ascertain the number of larvæ which reach maturity I examined on 30th May a green tree felled near Rajabhatkhowa on February 15th. From a circular section of a log 15 inches long taken midway up the length of the bole 60 grubs of various sizes up to apparently nearly full grown were cut out, this number giving 2,840 grubs in the 55-foot bole of tree. The tree proved a fair example of a badly attacked one. Larvæ examined when boring down into the heart-wood and excavating the pupal chamber were found to contain in their bodies a large amount of a peculiar white substance doubtless secreted by them for the purpose of preparing the white calcareous covering to the pupal chamber.

The pupal stage.

Pupæ have been taken from the pupal chambers in the heart-wood in February (on authority of Range Officer) and one which is probably this insect on April 28th. I think it possible that the insect pupates about February in the case of the beetles issuing in May-June, but in the case of those issuing in March it would probably pupate in November, and for those issuing in the autumn (if any do so) in May-June. The pupal stage is probably two to three months, it varying according to the time of the year the larva pupates.

The beetle.

The insect on assuming the beetle form remains quiescent in a resting condition in the pupal chamber, whilst the outer parts (consisting of chitin) slowly harden. It then breaks the calcareous covering closing the mouth of the pupal chamber (*vide* Pl. III) and makes its way up the broad larval tunnel in the heart-wood, which is always free of wood particles, since whilst boring it the grub probably feeds little and ejects from it the wood particles gnawed out, pushes or gnaws its way out through the mass of wood refuse in the broad larval galleries in the sap wood, and bites its way out through the bark, the escaping orifice always being a large one. In many instances I think the grub makes this exit hole before finally closing the pupal chamber, but that this is always the case I am at present doubtful.

The beetles appear to invariably leave the tree at night. Careful inspection has never disclosed the fact of any beetle boring or pushing its way out in the day-time. There seems, however, to be little doubt that the beetles, although they do not take wing readily, are active on cloudy, dull rainy days, and that they pair a good deal in dark shady places in the forest during the day-time.

Damage Committed in the Forest.

The damage committed by *H. spinicornis* in the Goalpara and Buxar Division Forests (I was only able to study it in these two divisions, but there is little doubt that the insect is present throughout the whole of the Sal belt of this part of India) is very similar to that already described in my note on its depredations in the Central Provinces and Chota Nagpur Sal areas. If anything it is probably an even more dangerous pest in the Assam Sal belt since (1) owing to the moister hotter climate its life cycle is a shorter one and therefore it increases with greater rapidity, and (2) the creepers have a much more luxuriant growth in the Assam areas and tend to induce sickness and loss of vitality in the trees toa much greater extent and thereby engender a state of growth particularly favourable to the attacks of the cerambyx. Observations would seem to show that this creeper growth is one of the greatest dangers the trees have to cope with in these forests. Not only is it in itself particularly harmful, eventually strangling the life out of the tree, but, if cut back too late, the tree has lost so much vitality from their effects that it falls an easy prey to both the longicorn beetle and the bark-borer *Sphærotrypes* which will be subsequently dealt with in this note.

Besides being a serious menace to the trees themselves, the beetle is equally noxious as a pest to the timber, and, unless barked, the wood of the trees felled in the forest will be found to be full of the larvæ within two or three months. Both logs and sleepers examined in the Hultugaon and Kachugaon Forests of the Goalpara Division and the Sal areas round Rajabhatkhowa in the Buxar Duars Division were found to contain the tell-tale holes made in the wood by the larvæ of this pest, and Mr. Perrée informed me that the depredations of the insect are now so well known and are of so serious a character that the most serious losses are suffered if barking is not undertaken at once.

I think it may be taken as proved that the beetle will not lay eggs in dead bark or even in bark or trees felled 2—3 months before it issues from the tree in which it has matured, nor will it lay in dry wood. That the beetle lays eggs in standing green trees was proved by Mr. Perrée himself finding a tree of this description which bore evidences of being attacked by the beetle. Woodpeckers had bored circular holes into the bark in several places to get at the grubs or pupæ. The tree had a girth of 3 feet and the top was absolutely green. We felled the tree and split up the last 18 inches of the stump above ground. In it were two full-grown larvæ pupating in their newly constructed pupal chambers, each chamber being covered with a newly formed calcareous covering and having a direct connection with the outside. In another pupal chamber a mature beetle was found just ready to emerge. This latter was in the heart of the tree. Many beetles had evidently previously issued from this tree, the stump being riddled with pupal chambers right down into the crown of the roots.

Method of Protection.

It is extremely important that every possible means of combating this insect in the forest should be made use of, since the damage it is capable of committing both from a sylvicultural and economic point of view is very great.

1. The most effective form of protection would of course be to only undertake fellings at such periods when it is known the beetle is not on the wing and therefore not egg-laying. It has been shown in the case of trees felled in February that no fresh eggs were laid on the bark by the beetles flighting in May. This would seem to prove that the beetles will not lay on the bark of trees two months or more old. Now the great increase or the presence of this insect in constant large numbers in areas where fellings are taking place is not so much due to the insects arising from eggs laid in the bark of the convertible bole, since the bole may have been barked and cut up before the larvæ have reached even half size, as to those bred in the large crowns of the trees which are left in the forest unbarked and unused owing to there being no demand for such wood. These are one of the great sources of danger, since it is impossible at present to hope to either make use of them or to get rid of them in any cheap manner. This source of danger can be minimised or entirely obviated by felling the trees, provided such a practice is possible, at times when the beetles are not present in the forest, and at least two months before they are likely to appear.

2. Bark every tree within a week of felling, and when possible remove the bark from the larger branches in the crown.

3. The numbers of the beetles present in a forest may be easily ascertained by felling trap trees at the periods when the beetles are on the wing. These trees should be visited every morning for at least a week after felling, and all the beetles found on the bark and in the adjacent low jungle growth should be collected. The bark should be removed from these trees at the end of the week, unless it is wished to study the life history of the insects further.

4. In the case of severe infestations of the beetles in a forest, a number of trap trees should be felled for the purpose of attracting the beetles to them to lay eggs. By collecting and killing all the beetles present, and barking the trees at the end of the week, a severe check will have been put on the increase of this pest. The bark

should be stacked and burnt, unless it can be exposed to a hot sun for a few days, which will serve the purpose required equally well.

Points in the Life History requiring further Observation.

There are two main points which require settlement with reference to the life history:—

(1) The exact periods of appearance of the beetle. According to Mr. Perrée it first appears in March. I have myself records of its being very abundant in May and June, and Rama Nath Mukerjee's observations carried on after my departure from Goalpara have proved that the beetles are very scarce in July. The question for confirmation is, does the beetle again appear in any abundance in September-October?

(2) The exact period taken by the larva to reach full size. This cannot be easily settled from the size of the grubs taken at any period since the beetles themselves vary enormously in size, the larva of course doing the same. When the time of appearance of the beetles has been settled we shall be in a position to make a definite statement as to the length of time spent by the larva in that stage of its existence.

INSECTS PREDACEOUS UPON HOPLOCERAMBYX SPINICORNIS.

2. ICHNEUMON sp.

Order—**Hymenoptera.** Family—**Ichneumonidæ.**

Nature of Attack.

This insect may be classed as a useful one in the forest, since the cerambyx beetle grub is parasitised by the ichneumon and finally killed by it.

Previous Record of the Insect.

I have no previous record of this insect.

Description.

Pupal covering or cocoon.—Smoky-grey, papery in texture, elliptical lozenge-shape with vertical sides. Length 1⅛ inch.

Fly.—Shining, elongate, slender. Head yellow; thorax red; basal part of wings, which are membranous, yellow, apical half black; tibiæ and tarsi black. Length about 1 inch. Described from a poor specimen taken dead from a cocoon. Pl. I, figs. 2, *2a*, shows the pupal case of this insect and the fly.

Life History.

The egg or eggs of this fly are laid by the female in the tunnel near or on the *Hoplocerambyx* larva. On hatching out the young parasitic grub feeds upon the tissues of the beetle larva either as an internal or external parasite. The former is not killed under the attack until it has reached its full size and formed its pupal chamber in the interior of the tree. This is evidenced by the fact that the beetle larva has strength enough to enclose its pupal chamber with the calcareous covering before it finally dies from exhaustion. The ichneumon grub then pupates in safety in the closed pupal chamber, first spinning a smoky-grey papery elliptical cocoon with vertical side walls, resembling an elliptical lozenge, as shown in the plate. How the fly gets out of the pupal chamber through the calcareous covering is not apparent. The only specimen taken was found dead in the cocoon. It is quite possible that the only chance of the fly getting out of the tree lies in its grub killing the beetle larva before it closes in the pupal chamber with the calcareous covering. That more than one ichneumon grub feeds upon the beetle one is evidenced by the fact that two of the papery cocoons were found side by side in the latter's pupal chamber. Although this fly does not prevent the damage being done to the trees, since it would appear that the larva forms, or nearly forms, its pupal chamber in the tree and therefore is not killed until it has done all the damage it can, the insect is of undoubted value in the forest, since it keeps down the number of future beetles. It is therefore of considerable interest that its life history should be fully worked out. Where the eggs are laid, the number laid in one beetle tunnel or on the larva, how the grub feeds upon the beetle larva, whether the latter is usually killed before making its calcareous covering to the pupal chamber, how the fly leaves the tree, and the number of generations of the insect in the year, are some of the points requiring investigation.

3. BOTHRIDES Sp.

Order—**Coleoptera.** Family—**Colydiidae.**

The grub of this beetle apparently feeds upon the Hoplocerambyx grub as an external or internal parasite, eventually killing the latter before it pupates.

Description.

Cocoon.—The cocoon consists of a yellowish coloured parchment material which appears to be made of very closely spun fine fibres of a ligneous nature. It is elliptical in shape and $\frac{1}{8}$ inch in length. (See Pl. I, Fig. 3.) The cover was spun with a few fine silk threads to the shrivelled skin of the cerambyx larva.

Beetle.—Elongate, narrow, reddish brown in colour. Thorax round, convex punctate. Elytra moderately convex punctate striate. Length $\frac{8}{16}$ inch. Fig. 3*a* shows the beetle and 3*b* a shrivelled skin of a Hoplocerambyx larva.

Life History.

In a larval gallery of *H. spinicornis* opened out whilst splitting up a green Sal tree felled in the Kachugaon Forests on May 16th, a black shrivelled skin of the grub of this beetle was found. The larva had been engaged in eating out the gallery in the heart-wood which finally terminates in the pupal chamber, and had died from exhaustion whilst engaged in this operation. Beside the shrivelled skin was the small elliptical cocoon described above. Both skin and cocoon were transferred to a tube and kept under observation.

An examination of the tube on May 19th disclosed the fact that one-half of the cocoon had been eaten down longitudinally, a reddish coloured beetle being observable inside. No material change occurred on the 20th. On the 21st an inspection showed that the beetle had eaten almost all the cocoon away and had emerged from it.

I explain the life history as follows:—The Colydiid larva feeds upon the longicorn grub either externally or internally, most probably the former, parasitically, the latter eventually dying of exhaustion. The parasite then spins a cocoon which it attaches to the drying skin of the dead grub and pupates.

Whilst this insect is a most useful one, further observations are required to ascertain its abundance in the forest before its value as an aid towards keeping down the Sal-borer pest can be decided. The points in the life history already given under the ichneumon parasite require investigation in the case of this insect also.

ATTACKS OF WOODPECKERS ON HOPLOCERAMBYX.

The large green woodpecker, which is fairly plentiful in the Goalpara Forests, drills holes in the green standing trees to get out the larvæ engaged in cutting out their pupal chambers or those already in the latter either in the larval or pupal stage. Whilst engaged in this operation the bird destroys the timber of the tree by making holes of a considerable size, which holes may subsequently become enclosed by a growth of later superimposed layers of wood. These, when the tree is not seriously infested, will result in greater damage to the timber than the mere presence of a few pupal chambers in the wood would have caused. At the same time the bird probably does a great deal of good by boring into and extracting grubs, etc., from badly infested trees the wood of which had been already irretrievably ruined by the borers. Pl. IV shows the trunk of a Sal tree badly riddled by woodpeckers in searching for Hoplocerambyx larvæ in the sap wood and heart-wood.

CHAPTER II.

II.—INSECTS INFESTING THE BAST LAYER AND SAP WOOD OF THE MAIN STEM AND LARGER BRANCHES.

In addition to the *Hoplocerambyx* four other longicorn beetles were found in the Sal trees, the larvæ of two of which commit more or less serious depredations in the phlœm of the tree, usually pupating in the sap wood. A third lives entirely in the wood and is described in Chapter III, whilst the life history of the fourth is still in doubt.

In the last published number of *Departmental Notes on Insects that Affect Forestry*,* it has been shown that a Scolytid bark-boring beetle, *Sphærotrypes siwalikensis*, Steb., seriously infests the Sal trees occupying the Siwalik Hills in the United Provinces. I had considered it probable that this insect would be present itself or be represented by a closely allied species in the other Sal tracts of the country, and this surmise has turned out to be correct in the case of the Assam, Bhutan, and Buxar Duar areas.

A species of Sphærotrypes, *S. assamensis* n. sp., was found infesting both green and dying trees and was in considerable abundance. A study of its life history has shown that, whilst it is somewhat similar to that of its Siwalik ally, it varies in such important details as the number of generations passed through in the year and in the length of time spent in each. It has also been indubitably proved in the case of the Assam Sal pest that it infests standing green trees.

4. DIALAGES PAUPER, Pascoe.

Order—**Coleoptera.** Family—**Cerambycidæ.**

Nature of Attack.

The eggs are laid by the beetle on the bark of living or newly felled Sal trees. The grubs on hatching out feed entirely in the bast and sap wood until full grown. They then bore down into the lower sap wood, eat out a pupal chamber in it, and pupate in this.

Previous Records of the Insect.

There appear to be no previous records of notes upon the life history of this insect.

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* No. 3, pp. 389—394 (1906).

Description.

Larva.—The grubs are of the ordinary longicorn type and are shown in Pl. V, Figs. 1, 1*a*. White with blackish-brown heads and mandibles and orange streaks on the thoracic segments. The youngest found was ¼ inch. Fully mature grub 1 inch in length.

Beetle.—Elongate, slender, brownish, with black patches on elytra. Antennæ fine, longer in male than in female; legs longish, slender. The thorax is constricted in front and behind. The elytra are narrow and covered with a greenish-yellow silvery pubescence. They leave a segment (pygidium) of the abdomen exposed behind. Under-surface yellow. Length ⅞ inch. Fg. 1*b* shows this insect.

Life History.

The eggs are evidently laid in the interstices of the bark of the tree. They probably soon hatch out and the young grubs feed at first in the bast. As they grow in size they feed in the bast and sap wood, mining out irregular galleries which are shallow and packed closely with woody excrementous particles. The larval galleries are roughly 8—12 inches in length or at times longer. The grub lives here until full grown. When it has finished feeding it bores into the sap wood at an angle to its previous direction, going in 3—4 inches, and then gnaws out a pupal chamber in the longitudinal axis of the tree. This pupal chamber is always made in the sap wood. Near the upper end it is covered over with a cap of some calcareous material white in colour and similar to that made by *Hoplocerambyx spinicornis*, but much smaller and without the keel-shaped edge. The gallery in the sap wood is square in section and one-fourth inch across. Length of the pupal chamber is 1½ inch.

The insect was found in both larval and beetle form on the 29th April. The larvæ were either quite young or mature. I do not know the length of time spent in the larval and pupal stages, but it is probable that the mature larvæ and the beetles found were those of the first generation of the year, and that the young larvæ were those of a second generation. As only a few beetles were found active it appeared probable that the majority of the insects had already left the tree and laid their eggs.

The insect may pass through several life cycles in the year.

Damage Committed in the Forest.

This insect is evidently plentiful in the Anguri Block of the Hultugaon Forest (Goalpara). Dead trees showed the sap wood often tunnelled out from top to bottom with the larval galleries, and dead beetles were cut out from the pupal chambers in such trees. Stag-headed or dead tops of living trees also showed the evidences of past attacks. Lower down in the green still-living portion of the stem grubs were found at work and also beetles just ready to emerge. The insect would appear to be a pest of considerable importance since the grub feeds entirely in the bast layer and sap wood, entirely destroying the latter when numerous. A dead tree examined showed the whole of the bole from top to bottom covered with a mass of old larval galleries, proving that the whole of the cambium layer of the tree had been finally destroyed by the insects. It is not improbable that the trees are reduced to the sickly condition best adapted for the attacks of this insect by being partially strangled by the creepers which infest these forests. The insect is also favoured by being able to lay in all newly felled trees and unbarked tops left in the forest.

The cause of death of the beetles found in the pupal chambers has not been discovered, but the insect is apparently parasitised by the ichneumon fly described below.

Points in the Life History requiring further Observation.

The most important points to be discovered about this insect are:—

(1) The number of eggs laid; how laid, whether singly or in patches; and how long they take to hatch out.

(2) The number of generations passed through in the year and the length of time passed by each in the various stages of egg, larva, pupa, and beetle.

(3) The cause of death of the beetles found dead in the pupal chambers.

AN INSECT PARASITIC ON DIALAGES PAUPER.

5. ICHNEUMON Sp.

Order—**Hymenoptera.** Family—**Ichneumonidæ.**

Nature of Attack.

The ichneumon grub feeds upon the Stromatium larva as an external or internal parasite, finally killing it.

Previous Records of the Insect.

There are no previous records of the insect.

Description.

Cocoon.—Smoky-grey, flat elliptical in shape and consisting of a very thin, shining, papery material.

Fly.—Elongate, slender, shining orange red. Head dark red with black, rather short antennæ and a long curved ovipositor longer than the total length of the insect; the wings are membranous, slightly longer than the insect; anal tips with smoky bands and upper wings with three black spots, two on the exterior edge of the upper half and one on the inner edge in a line with the lower spot. Length about ¾ inch. Figs. 2, 2*a* show the cocoon and fly.

Life History.

This ichneumon would appear to lay its eggs in the neighbourhood of those of the longicorn or on the grub itself after it has hatched out. The parasite feeds upon the latter, but does not apparently eventually kill it until it has eaten out the pupal chamber and closed it over with the calcareous covering. The parasite then leaves its host, the latter shrivelling up, and spins the papery elliptical cocoon and pupates inside it. I do not yet know at what period or periods the fly issues since I have only taken dead flies *in situ* in the pupal chamber. They were taken from pupal chambers in the tree in which the dead beetles were discovered.

A good deal remains to be discovered about the life history of this insect. How many life cycles the ichneumon passes through during the year, how its grub feeds upon the longicorn one, how the fly gets out of the closed pupal chamber, and its abundance in the forest, are some of the points which present themselves for decision.

6. CALOCLYTUS Sp. near SIGNATICOLLIS, L. AND G.

Order—**Coleoptera.** Family—**Cerambycidæ.**

Nature of Attack.

The larvæ of this beetle feed in the bast layer of the tree eating out small shallow winding galleries in the bast and sap wood, and thus causing a certain amount of injury to the tree. The insect if present in large numbers in saplings and young poles would be capable of killing the tree.

Previous Records of the Insect.

I have no records of this insect having been reported as infesting the Sal tree.

Description.

Beetle.—Elongate, slender, with short antennæ. Canary-yellow with a circular black spot on the dorsal surface of the thorax and wavy transverse bands of the same colour on the elytra. Head black behind with a yellow pubescence covering the front. The canary-yellow colour is caused by a thick short pubescence. The black lines on the elytra consist of an ellipse in the shoulder and two transverse lines, one placed medianly and the other near the apex. Under-surface canary-yellow. Length ¾ to 1 inch. Pl. V, Fig. 3, shows this beetle.

Life History.

I cut a dead specimen of this beetle from the sap wood of a large branch of one of the trees felled for the purpose of making observations on the attack of Cerambyx sp. (p. 33). Old larval galleries showed that the grubs feed in the cambium and sap wood until full fed, when they bore down at an angle for an inch or so into the sap wood and hollow out a pupal chamber in this and pupate in it.

These are the only notes I have at present upon the life history of this insect.

7. THYSIA WALLICHI, HOPE.

Order—**Coleoptera.** Family—**Cerambycidæ.**

Nature of Attack.

According to Mr. Perrée this insect lays its eggs on the Sal trees, and the grubs on hatching out tunnel into and live in the Sal wood. There is, however, as yet no corroborative evidence that this is the case.

Previous Records of the Insect.

I have at present no previous records of this insect. It has originally been reported from Assam, but its food plant does not appear to have been recorded.

Description.

Stout, thick set, and robust with long powerful legs. A brilliant green with reddish markings. The antennæ have a few whorls of hair (circular brushes) on them. Under-surface brilliant red. Thorax ridged produced into a blunt point medianly at the sides, smooth. Elytra with well-marked shoulders, thickly punctate; a circular brush of black hair arises from middle on the basal third and a small transverse one at same level near lateral margin; a transverse black band of hair on the middle and apical thirds; legs shining indigo-green. Length $1\frac{5}{8}$ inch. The beetle is figured in Pl. V, Fig. 4.

Life History.

This extremely handsome cerambycid was taken plentifully on the wing in the Kachugaon Sal Forests in Goalpara during May. It flies by day, settling in the sunlight upon the bark of green standing or felled trees. The beetle was pairing between the 13th and 23rd May. I was unable to ascertain definitely where this insect came from. It may, as Mr. Perrée suggests, lay its eggs on the Sal and the grubs may feed in the tree. I myself, however, think it possible that it may prove to be a Sal girdler, girdling the branches or leaders of young saplings and laying its eggs in the part girdled.[*] Its life history requires working out.

8. SPHÆROTRYPES ASSAMENSIS, n. Sp.

Order—**Coleoptera.** Family—**Scolytidæ.**

Nature of Attack.

The beetle lays its eggs in the green bast layer of the tree and the grubs on hatching out feed in this; when numerous the greater portion of the phlœm may be consumed and the tree dies. Several generations of the insect appear during the year.

Previous Records of the Insect.

I have no previous records of this insect which is closely allied to *S. siwalikensis*, Steb. It differs from *S. coimbatorensis*, Steb. from the Coimbatore Hills.

Description.

Larva.—White, short, squarish in outline, dorsal surface slightly convex. Head small, yellow. In appearance resembles a large white tick.

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[*] *Vide "Injurious Insects of Indian Forests,"* pp. 66-67 (1899).

Pupa.—White, short, and squat with a small distinct head.

Beetle.—Small, convex, globular, very convex above, black, slightly shining. Thorax uniformly punctate with a slight longitudinal median line. Elytra with deep longitudinal striæ and longitudinal rows of elevated prominent black scales between them. There is a row of stiff short hairs on the anterior margin of the thorax. Easily distinguishable from *siwalikensis* by the deeper striæ on elytra which become more pronounced as they approach the apex instead of obsolete, in the black colour of elytra and in the more open and definite punctation of elytra; also in the more strongly raised line of thorax. Easily distinguishable from *coimbatorensis* (as is also *siwalikensis*) by the much more obtuse angle formed unevenly by the junction of the bases of the two elytra, the angle being sharply V-shaped in *coimbatorensis*; the larger size also distinguishes it from this latter. Undersurface black finely punctate, Antenuæ yellow, tarsi piceous brown; tibiæ set with an edge of white hairs. Length $\frac{1}{7}$—$\frac{1}{8}$ inch. Pl. V, Figs. 5, 5 *a*, 5 *b*, show the larva, pupa, and beetle.

Life History.

The beetle makes its first appearance sometime early in March and lays its eggs in the phlœm of newly felled trees or in standing sickly ones. The upper part of the trunk and the crown of a large green tree felled in February were found to have been badly attacked soon after felling, the generation of beetles raised in them having issued at the end of April, and in the middle of May had already oviposited in neighbouring trees. None of these beetles or others of the same generation had oviposited in the bark of this tree since it had become too dry. They require absolutely green cambium. The male beetle bores down about ¼ inch into the bark of the main stem or thicker branches at an angle and hollows out to one side of the tunnel a small chamber, large enough to afford space for two beetles. (Pl. V, Fig. 5 *c*.) This is the pairing chamber. The female usually enters the pairing chamber by boring a separate tunnel through the bark which hits off the chamber. She is fertilised by the male and then continues the entrance tunnel down to the phlœm. On reaching this she eats out a gallery in the longitudinal axis of the tree approximately at right angles to the entrance tunnel. This is the egg gallery and is about an inch in length.

The eggs are laid in this and the larvæ hatch out and mature in a manner similar to that already described in my *Departmental Notes* for *S. siwalikensis*, p. 389. The larval tunnels are winding; they increase in size with the growth of the grub, and are tightly packed with the wood excreta. The plan of egg and larval galleries is very constant and uniform, forming a bluntly rounded ellipse. When numerous the beetle will lay its eggs in small branches. On these the bark is necessarily too thin for the beetle to hollow out its pairing chamber in it, and instead this latter is made in the sap wood and phlœm. The egg gallery is commenced to one side of the pairing chamber, the latter being usually situated about ⅛ inch up the former and to one side. The egg gallery is not invariably straight. It may be curved or even bent sharply to one side, but this latter is not usual. It was especially visible in the case where the insects were egg-laying in very green trees. The number of eggs laid is 35—40 on each side of the gallery, or 70—80 in all per beetle, and the larval galleries are 2 inches in length. The male beetle remains alive whilst the female is eating out the egg gallery and ovipositing, and is usually to be found blocking the entrance tunnel near the pupating chamber. Since the beetle is preyed upon by a species of *Niponius* described below, which enters the tunnels of the bark-borer, the continued presence of the male would seem to be for the purpose of protecting the female.

At the end of April the insect was taken in the full grown larval, pupal, and immature and mature beetle stages in trees in the Hultugaon Forest (Goalpara), this being evidently the first generation of the year. A proportion of the beetles had already issued and were egg-laying in other trees. A comparison will thus show that this insect in Assam is nearly a generation ahead of its confrère *S. siwalikensis* of the Northern India Sal areas. The fact that a generation of beetles has left the tree can always be seen on the outside of the bark, as, owing to the ends of the larval galleries, *i.e.*, the pupal chambers, being all situated on the circumference of an ellipse, and to the fact that the mature beetles bore straight out of the bark from the pupal chamber in the bast layer and sap wood, a regular series of exit holes forming an ellipse is to be seen on the outer bark. The beetles leave the trees in which they have matured in swarms together at night and search for suitable trees in which to oviposit. By the middle of May the beetles of the first generation of the year were busily egg-laying in the Kachugaon Forests and some larvæ had already hatched out and commenced to eat out their galleries. At the end of the month some of these latter were already two-thirds grown both in the Kachugaon Forests and in the Rajabhatkhowa Sal areas. This is as far as the life history has been carried. I am of opinion that it will be found that the insect has at least five generations in the year, the beetles of the second appearing the first or second week of June; those of a third at the end of July; a fourth in the middle of September; and a fifth towards the end of October. It is the grubs and the beetles of this latter generation which hibernate through the winter and egg-lay in the following March. As soon as the first snap of cold makes itself felt, the grubs will leave off feeding and remain in a comatose condition in their galleries. The beetles which have already issued probably do as their Northern India ally does, and bore into the thick bark of Sal trees and hibernate in this. It is not impossible that in the hot damp climate of Assam, in favourable seasons, the October beetles may pair and oviposit at once, and that a sixth generation may be passed through before the advent of a cooler temperature puts a stop to their work.

Damage Committed in the Forest.

This bark-borer must be ranked as second only to the *Hoplocerambyx* in its power of committing damage in the Sal areas. It has not the latter's capacity for destroying the timber since it never goes into it, merely grooving the outer sap wood. When numerous, however, it is equally as dangerous as a phlœm consumer and probably more so since it will attack young saplings. During its flighting periods it makes its appearance on newly felled trees as soon as the *Hoplocerambyx* beetle and will enter the tree to oviposit in any part of it save the smallest twigs. In addition to attacking sickly standing trees in the forest it also makes attempts on healthy green standing trees. Several instances of this nature, in which trees had been attacked by the March generation of beetles or those of a generation of the past year, were noted; from the appearance of the galleries it is simple to approximately fix the period at which they were made. The trees in question responded with a copious outflow of sap which either drowned the beetles in their partially completed egg galleries and killed the eggs and the young grubs, or drove the beetles from the tree to seek more favourable situations. Instances were seen where the beetle had maintained the struggle and laid its eggs, but it was noticeable that in these cases the egg galleries were either longer, a small number of eggs only being laid which hatched into larvæ which bored long galleries, the number being reduced to a dozen; or the egg galleries were very short and narrow, the eggs being mostly laid on one side only, the larval galleries being small and short. The egg galleries bored in such trees often curve (*vide* Pl. V, Fig. 5 *d.*). Trees which had successfully resisted a bad attack by the February generation were, however, succumbing to that of the May one. A large tree, 5 feet in girth and 100 feet in height, the leaves of the upper part of the crown of which had but recently turned brown and withered, was felled in May and examined. It was found to have been unsuccessfully attacked in the manner above described by the March generation. The May one had better success and the crown and upper one-third of the stem were full of beetles and newly hatched grubs. No other cause for the dying condition of this tree could be found, although the upper portions of the roots were laid bare in search of a possible root fungus. The *Hoplocerambyx* had not yet appeared in the tree.

I have already alluded to the damage creepers do in these forests. They were cut over in the Sal areas near Kachugaon (Polo and Hel Blocks) three years ago. It is possible that many of the trees attacked in these localities by these beetle pests may have formerly been partially strangled by the creepers and thus had their vitality greatly reduced. Before they have been able to recover strength they have been attacked by the insects with the present deplorable results.

Methods of Protection.

Methods for the protection of forests from the attacks of bark-boring pests of this nature have already been discussed when considering the life history of *Sphærotrypes siwalikensis,** and it will be unnecessary to detail them again here.

The method of ascertaining the numbers of the insects in the forest and of trapping them by using felled trees as described under *Hoplocerambyx* can also be resorted to in the case of this insect. In May the same trees will do for both since at least one generation of the *Sphærotrypes*, and probably the March one also, coincides with the appearance of the *Hoplocerambyx* beetles in the forest. For the other periods the trap trees should only be destroyed, *i.e.*, barked and the bark burnt (the timber is not affected by this insect) when the beetle was not on the wing in the forest, *i.e.*, when the insect was in the bark and sap wood either as larvæ, pupæ, or immature beetles.

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* *Departmental Notes,* Vol. I, pp. 392-393 (1906).

Points in the Life History requiring further Observation.

The most important point requiring solution is the number of generations appearing in the year. This can be easily settled by felling a green tree once a fortnight all through the year and recording the periods at which beetles visit the felled trees. The reason for felling a tree so often is that the beetles will not oviposit in bark at all dry.

2. It is also necessary to ascertain the exact periods passed in the larval, pupal, and beetle stages in each generation since upon that depends the periods at which trap trees should be felled. It is probable that there is some over-lapping of the generations, since the beetles which have hibernated through the winter lay eggs earlier than those which have passed the winter as grubs. It may be taken, however, as probable that the main flights of beetles will appear at definite intervals, and it is to catch the progeny of these that trap trees are recommended.

9. SPHÆROTRYPES Sp.

In May 1902 I found a species of *Sphærotrypes* tunnelling into a small green shoot of a green Sal sapling in the Dehra Dun Sal Forests. The beetle was alive and only the extremity of its body was visible on the surface of the sapling, the rest of the insect being buried in the shoot.

On two occasions in May I took in the Kachugaon Forest a *Sphærotrypes* beetle buried in a living shoot of a Sal pole, only the extremity of the body of the beetle being visible from outside. In each case the tree had been felled to examine it for other boring insects, and the *Sphærotrypes* beetles were in the upper branches in the crown of the tree. There is now no doubt that the beetle, whether the same species or not, does tunnel into green shoots, and it may do so for feeding purposes only or it may egg-lay in this position. I think the first explanation the most probable.

INSECTS PREDACEOUS UPON SPHÆROTRYPES ASSAMENSIS.

10. NIPONIUS ANDREWESI.

Order—**Coleoptera.** Family—**Histeridæ.**

Reference :—*Departmental Notes*, Vol. I, p. 401.

Nature of Attack.

The grub of this beetle lives in the galleries of the *Sphærotrypes* bark-borer feeding upon the grubs of the latter, whilst the mature *Niponius* preys upon the bark-boring beetle itself, seeking it out whilst it is engaged in mining out the entrance gallery in the bark or entering this and attacking prey in the egg gallery.

Previous Records of the Insect.

This insect has not been previously reported from Assam. It was first taken by Mr. T. R. D. Bell, I.F.S., in Kanara in the Bombay Presidency. I subsequently found it preying upon *Sphærotrypes siwalikensis* in the Dun and *S. coimbatorensis* in the Coimbatore Hills in Madras. The discovery of this insect in Assam indicates that it is widely spread throughout the continent.

Description.

I add the following to my descriptions given in *Departmental Notes*, Vol. I, p. 401 :—

Pupa.—Small, white, elongate and straight. (*See* Pl. V, Fig. 6.)

Life History.

I give the following notes on the life history of this insect in Assam in April and May to supplement the notes already given in *Departmental Notes* for other periods of the year in different localities.

Larvæ were taken in the galleries of the mature grubs of *Sphærotrypes* in the Hultugaon Forests at the end of April. On the 14th May I took a specimen of the beetle in a partially complete egg gallery of a *Sphærotrypes.* The bark-boring beetles had been eaten by it. On the 21st of the month I took a number of beetles engaged in devouring the bark-borers which were attacking the large green Sal tree mentioned on p. 24. In addition to searching out the bark-boring beetles I think the histerid also enters the egg galleries for the purpose of laying its eggs close to those of the *Sphærotrypes*. The pink grub is, however, very active and does not appear to confine itself to any one set of larval galleries, since it is often found between the bast and sap wood worming its way on to neighbouring galleries remote from the one where it hatched out. The eggs of the *Niponius* do not hatch as soon as, or at the same time as, those of the bark-borer, since no young larvæ were present in any of the egg and short larval galleries found so numerously in the latter half of May. The abundance of this insect is by no means yet satisfactorily settled. In the three localities I have found it in it has only been sparingly taken. This may, however, be easily accounted for by the fact that it is only to be found in the larval galleries of its host from which it has to be laboriously cut out. I have rarely taken it on the bark of the tree. It apparently hides until it can safely enter a tunnel already extending down to the bast layer.

This insect is of such importance that the remainder of its life history urgently requires working out. We require to know whether the number of generations it passes through coincide with those of the *Sphærotrypes* and the exact number of them. The larval and pupal stages and beetle stages of the first generation of the year, March to May, would appear to coincide with those of the insect it preys upon, and it is not unlikely that the remaining life cycles of the year will be found to do so.

11. THANASIMUS ASSAMENSIS, n. sp.

Order—**Coleoptera.** Family—**Cleridæ.**

Nature of Attack.

This insect is an excessively voracious and predaceous one. It attacks the bark-boring *Sphærotrypes* beetles with great eagerness and devours them with great avidity. It is also predaceous upon the *Platypus* beetles described on p. 41.

Previous Records of the Insect.

I have no previous records of this insect, which I consider to be new to science. It is closely allied to *Thanasimus himalayensis* Steb. which devours bark and wood-boring Scolytids in the North-West Himalayas.* It will doubtless be found that either it or a closely allied species feeds upon *Sphærotrypes siwalikensis* in the Dun and neighbouring Sal tracts.

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* *Departmental Notes*, Vol. I, p. 213.

Description.

Beetle.—Squarish, with an ant-like vertical head and "shoulders" to the elytra which give it some superficial resemblance to a longicorn beetle. Black with transverse white bands on the elytra. Antennæ knobbed. Head black, shining, a few scattered black bristles on vertex, the front being set with close long white hairs. Eyes black, prominent. Thorax red, shining, with a deep transverse depression across the middle and a marked channel just above the basal margin. Clothed with scattered stiff long black bristles, a bunch of white ones projecting from the lateral margins just above the base. Elytra black set with rough scales. A band of white pubescence, under which the elytra are yellowish red, starts from the base on either side of the median suture and is produced upwards for about a third, when it expands laterally to the outer edges in the form of a broad transverse white band whose apical margin is produced medianly into a sharp point reaching to the upper third of the elytra. A second narrower white transverse band traverses the elytra just above the apices which are black clothed with more sparsely set white hairs. Under surface black, the thoracic segments clothed with long thick sickly white hairs most numerous laterally. Upper portions of pimora yellow, rest of leg black clothed with long yellow and white hairs. Antennæ yellow. Length ¼ inch. Pl. V, Fig. 7 shows this beetle.

The smaller size and position of the white bands on elytra easily distinguish this species from *himalayensis*.

Life History.

This insect was first taken on the wing whilst proceeding through the Hultugaon Forests on an elephant. It was subsequently caught flying round and running about on the bark of newly felled Sal trees in the Kachugaon (Polo and Hel blocks) Forests. It is an extremely active insect resembling a *Cicindela* in its movements, as it flies and runs with great rapidity. Beetles were kept for some days and fed with living *Sphærotrypes* and *Platypus* beetles. They were found to consume a considerable number of the bark and wood beetles per day, taking about 15 minutes to eat one *Sphærotrypes* beetle. Their habits, method of feeding, etc., are similar to those already described for *T. himalayensis* in *Departmental Notes*. There is still a considerable amount of information required about this very useful insect. We require to find its grubs which almost certainly feed upon the bark and wood-boring Scolytid grubs. Also where the eggs are laid and whether the generations of the beetle coincide with those of its hosts.

12. PLATYSOMA Sp. (245 and 246, 1906).

Order—**Coleoptera.** Family—**Histeridæ.**

Nature of Attack.

This histerid is predaceous upon the bark-borer *Sphærotrypes assamensis*, and it may also feed upon the eggs and young larvæ of *Hoplocerambyx spinicornis*.

Previous Records of the Insects.

I have no previous records of this insect.

Description.

Beetle.—A compact, shining, black beetle, squarish in build with a hard integument; elongate, pointed mandibles. Head and thorax very smooth and shining. Elytra smooth, shining, with a few longitudinal striæ placed wide apart. They leave the last two segments of the abdomen exposed, the last being constricted behind. These segments are thickly and deeply punctate. Length ¼ inch. (*Vide* Pl. V, Fig 8.)

Life History.

Only a few specimens were taken. They were found beneath the bark of the Sal tree felled on 13th May in the Kachugaon Forests which was subsequently infested by both the hosts of this insect. They attack the *Sphærotrypes* beetles and may eat their eggs and larvæ also.

Use in the Forest.

Both these insects are of considerable use, provided they exist in sufficient abundance to exercise a salutary check on the bark-boring pest. This I have not yet ascertained. Any insect predaceous upon a pest is, however, of great value, and the life history of these *Platysoma* beetles requires working out. The number of generations in the year, period passed in larval stage, and food eaten by larvæ, etc., all require to be studied.

CHAPTER III.

III.—INSECTS INFESTING THE WOOD OF THE MAIN STEM AND BRANCHES.

13. CERAMBYX? sp.

Order—**Coleoptera.** Family—**Cerambycidæ.**

Nature of Attack.

The damage is done to the tree by the grub of the beetle, saplings and young poles chiefly suffering from the attacks. The grub feeds in the centre of the stem, boring galleries which subsequently become buried in the interior of the heart-wood of the tree by superimposed layers of woody growth. The heart-wood of large trees attacked whilst young by the larva of this insect is thus often ruined as timber.

Previous Records of the Insect.

As only larvæ, as yet, have been procured, it is not possible to say what species of cerambycid beetle commits this damage. It may be pointed out, however, that it greatly resembles in its nature the attacks of the species of Cerambyx which infests the wood of the sandal tree in Coimbatore in the Madras Presidency.*

Description.

Larva.—Elongate, white, smoky-black at the juncture of the segments. Head and mouth parts black. Prothorax swollen, prominent, hood-like, pointed anteriorly; yellowish with two characteristic transverse orange lines dorsally, one placed anteriorly, the other posteriorly. Segments following the prothorax narrow and taper to a little behind the middle and then increase in size to 10th; 11th and 12th again taper posteriorly, the 12th ending in a blunt point. Thoracic segments with three pairs of small feet. Segments are fairly well marked and ridged. Length 1½ inches (not full grown). *Vide* Pl. VI, Fig. 1.

Life History.

The egg is laid either in the cambium layer or deep down in an interstice of a branch. The young grub evidently enters the wood soon after hatching and usually bores down the centre of the branch towards the main stem. On reaching the main stem the tunnel is carried down the centre of it in the hardest wood. (*Vide* Pl. VI, 1a). In order to keep the gallery aërated horizontal offsets are eaten out until the outer bark is pierced, the external orifice being very small so as not to attract predaceous insects, woodpeckers. In the case of saplings the egg is laid direct on the main stem and the grub on boring in at once turns downwards on reaching the centre of the heart-wood. The beetle will apparently lay anywhere on the stem of a sapling down to within six feet of the base. No larval tunnels have been found below this height. The larval gallery is blocked here and there with wood excreta, and it is probably owing to this and to its length that the grub finds it necessary to bore the aëration offshoots to the outer air. When full fed it pupates at the end of its tunnel, the space occupied by the grub at this juncture and a small length immediately above it being quite free of wood-dust and excreta. When mature the beetle apparently bores directly out of the tree, the exit gallery being straight and horizontal.

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* *Vide* my Note on the Sandal-wood Insect Pests of Madras, Ind. For. XXIX, Appendix Series, pp. 2 to 7 (1903).

Damage Committed in the Forest.

Green Sal trees infested by this grub were split up in the Guma Reserve, Borobadha (Goalpara). The heart-wood of trees from 3—4 feet girth and over was found to be completely riddled with the galleries of this insect, although the trees showed no signs externally of having been infested. The wood had already been rendered useless as timber, although the trees were still growing vigorously. Some of the galleries showed evidence of considerable age, being at times partially overgrown with new outgrowths of wood which completely blocked the aëration orifices and the exit one of the beetle. It is this aftergrowth of wood by the living tree which renders the attack at first sight a perplexing one, since all evidence of it becomes buried in the interior of the tree. Also the wood excreta blocking the tunnel often either under the influence of sap or percolating moisture, solidify into a fibrous woody structure which at times conceals the gallery.

Since the grubs live from an early age in the wood they do little damage to the cambium layer and probably never cause the death of the tree.

Until we know more about the life history of this insect and have obtained specimens of the beetle, it is not possible to prescribe any methods of protection against it.

Points in the Life History requiring further Observation.

This pest is one of considerable importance since its increase in the forest, and especially in areas of young Sal saplings and poles, would result in the monetary value of the trees as timber becoming gravely depreciated, and this at an early age. It is therefore essential that its life history should be worked out.

The points to be decided are :—

(1) The periods of appearance of the beetle in the forest.

(2) The number of eggs laid by the beetle and the number of grubs ordinarily reaching maturity after hatching from the eggs.

(3) The economic abundance of the pest.

(4) The periods passed through in the various stages of egg, larva, pupa, and beetle.

(5) The number of generations, if more than one, passed through in the year.

SCOLYTID, PLATYPID, AND BRENTHID WOOD-BORERS.

Nature of Attack.

The following Scolytid, Platypid, and Brenthid wood-borers were all taken from the wood of newly felled, or in some cases standing sickly, green trees in the Kachugaon Forests. They tunnel directly down into the sap and heart-wood for the purpose of laying their eggs in the wood.

Previous Records of the Insects.

There are, as far as I am aware, no records extant concerning any of these insects, all of which appear to be described here for the first time.

14. PHLŒOSINUS MAJOR, n. sp.

Order—**Coleoptera.** Family—**Scolytidæ.**

Description.

Larva.—Short, thick, white, but slightly curved, legless. Body corrugated. Length .

Pupa.—Short, thick, whitish yellow, having a resemblance to the beetle.

Beetle.—Robust and thick; moderately shining. Thorax reddish. Elytra dark reddish brown. Head large, vertical, dark brown; punctate, with a weak median line and a fringe of yellow hairs at base of mandibles. Thorax but slightly broader than long, very convex, culminating in a prominent peak on centre of disk; thickly pitted on anterior half, the posterior portion smooth and shining on disk slightly pitted on sides. Sprinkled with long yellow hairs anteriorly. Elytra wider than thorax, not quite twice as long, convex and constricted posteriorly, the declivity with longish yellow hairs; longitudinally striate and squamulose. Under-surface pitted with a scanty pubescence. Antennæ and legs yellowish brown. Length $\frac{7}{32}$ inch. Pl. VI, Figs. 2 and 2 *a* show this beetle and Fig. 2 *b* the borings in sal wood.

Life History.

The beetle, which is the largest of the Scolytid borers at present known as infesting the Sal tree, bores a single tunnel down through the bark into the sap wood. This is probably the work of the male. It goes in for about ¼inch. At the end the insect hollows out a pairing chamber. Two females are apparently fertilised here by the male, or possibly sometimes three. After pairing each female tunnels away at an angle from the pairing chamber either to the right or left, or if there are three females the third will go directly downwards. In the gallery of a female carried to the right which was examined on 20th May, I took out, about 2 inches down, 2 pupæ and 3 nearly mature beetles (males and females). They were all in the one gallery, to which there were no offshoots, and had a diameter equal to that of the tunnel in which they closely fitted. As there were no offshoots to the egg tunnel nor any indication of the grubs having lived upon wood, it is probable that they belong to the class of ambrosia feeders and live upon fungous growths lining the walls of the tunnels. The question arises, are the pupæ and nearly mature beetles found in the wood in the latter part of May those of the first generation of the year? I think this possible. Beetles were also found tunnelling into newly felled trees within four days of the latter being cut, evidently with the object of pairing and egg-laying. It is thus probable that there are at least two, if not more, generations in the year.

Damage Committed in the Forest.

The beetle itself bores down into living green wood of standing trees which is a peculiar habit. It probably only infests sickly trees with stag-headed tops, but it is never found in the dead parts of the tree. Several green standing trees infested were examined. The dead tops invariably showed that they had been tunnelled into in previous years by the beetle. Below the dead parts near the junction of the old dead and the live green wood it will be found at work. The beetle ruins the timber of the tree when very numerous.

15. PHLŒOSINUS MINOR, n. sp.

Order—**Coleoptera.** Family—**Scolytidæ.**

Beetle.—Smaller than the last. Short, compact, convex, dull brown, with a largely developed hood-like reddish brown thorax. Head small, dull brown, hidden beneath thorax, punctate. Thorax convex, slightly wider than long, closely squamose behind, more open in front. Elytra black, convex, rounded, truncate behind; a little more than 1½ time as long as thorax; longitudinally striate-punctate, punctures few. Surface of elytra and thorax with scanty stiff yellowish hairs. Under surface black, shining; legs brownish. Length $\frac{5}{32}$ inch. Differs from *P. major* in smaller size, different shaped thorax with no diskal peak and the squamose surface of thorax. (Pl. VI, Fig. 3.)

Life History.

This beetle is found on the wing in the middle and third week in May. The beetle bores straight down into the wood of newly felled green Sal trees (and probably into that of standing sickly ones) to oviposit. A beetle was cut out of a tree on the 16th, the tree, a green one, having only been felled three days before. The insect was engaged in eating out its egg gallery. The presence of the insect can be easily recognised owing to the fact that little cylinders of ejected saw-dust are to be seen projecting from the entrance holes in the bark. The colour of these, whether white or reddish, indicates whether the beetle is in the sap or heart-wood. The beetles found in May were probably those of the first generation of the year just matured.

16. DOLURGUS ? sp.

Order—**Coleoptera.** Family—**Scolytidæ.**

Description.

Beetle.—Elongate, slender, reddish brown. Apical portions of elytra sharply constricted into blunt points, antenna with a 3-jointed funiculus, the club with two transverse bands of light yellow hairs. Thorax constricted behind and truncate anteriorly, truncation blackish and finely tuberculate; the disc shining and very finely punctate. Elytra constricted sharply to a point behind; basal portion red and finely punctate, the remainder becomes blacker in colour as apex is reached, the surface scaly and punctate and clothed with scattered yellow hairs. The curious constricted apices of the elytra are a marked characteristic of this insect. Length ⅛ inch. Pl. VII, Fig. 1, shows a dorsal and side view of this beetle.

Life History.

Only one specimen of this scolytid has been yet taken. It was found tunnelling down through the bark of the Sal tree felled in the Kachugaon Forests on the 13th May. The beetle was taken on the 16th.

17. DRYOCETES sp.

Order—**Coleoptera.** Family—**Scolytidæ.**

Description.

Beetle.—Short, elliptical convex reddish brown. Thorax set with several transverse bead-like prominences anteriorly, punctate posteriorly. A prominent elevated longitudinal median line not reaching to posterior margin. Elytra punctate striate, truncate posteriorly, the truncation smooth and sloping; covered with stiff sparse hairs. Length ⅛ inch. (A single specimen damaged.) Pl. VI, Fig. 4, show this beetle.

Life History.

I have only taken one specimen of this beetle. It was found on May 16th tunnelling into the sap wood of the green tree felled on the 13th.

18. TOMICUS SHOREÆ n. sp.

Order—**Coleoptera.** Family—**Scolytidæ.**

Description.

Beetle.—Elongate, rather slender with an elongate convex reddish thorax and dark piceous elytra. Thorax $\frac{1}{6}$ longer than broad. Moderately strongly tuberculate anteriorly with a few scattered yellow hairs and finely pitted on posterior extremity with irregular fine, transverse lines and striations. Elytra irregularly punctate with an ill-defined stria not reaching base and the suture prominent. The apical declivity of elytra furnished with 3 prominent teeth on each side and 3 smaller ones. Some scattered hairs on the surface. Under surface slightly punctate with scattered hairs. Legs and antennæ yellowish red. Length $\frac{1}{8}$th inch.

Life History.

I have only taken three specimens of this insect. They were all taken on 16th May tunnelling down into the sap wood of the green tree felled in the Kachugaon Forest on the 13th of the month. They were in the main trunk. This is all the information at present available on this insect. (See Pl. VI, Fig. 5.)

19. TOMICUS sp. (242—1906).

Order—**Coleoptera.** Family—**Scolytidæ.**

Description.

Beetle.—Dark brownish black. Chief characteristic is the prominent median tooth of the elytral declivity armature. Thorax longer than broad but shorter than in *T. shoreæ.* Set with transverse scales anteriorly decreasing in size to centre. Posterior portion finely pitted, the fine irregular lines and striations being absent. Elytra very irregularly punctate with no prominent striæ. Elytral declivity with the median tooth very prominent curved inwards and larger than the others. Length $\frac{1}{10}$inch. (See Pl. VI, Fig. 6.)

Life History.

I have only taken one example of this insect which is apparently rarer than the others described. It was found tunnelling down towards the sap wood through the bark of the tree felled on the 13th instant. It was taken in the main trunk of the tree.

20. ACANTHOTOMICUS TRUNCATUS, n. sp.

Order—**Coleoptera.** Family—**Scolytidæ.** Sub-Family—**Tomicini.**

Description.

Short, compact, with elytra abruptly truncate behind, the truncation being circular in section. Thorax reddish yellow, elytra ferruginous black. Thorax set with moderate sized scales anteriorly and finely punctate posteriorly. Scutellum small rounded. Elytra as long as thorax, smooth with fine longitudinal striæ; apex abruptly truncate, the truncation being circular in section and studded with small projections, and elevations, the sutural ones at the top of the declivity being most prominent, a few spiny hairs on declivity. Under surface reddish yellow, set with yellow hairs on anterior portion. Abdominal segments punctate legs and antennæ yellow brown, latter pubescent. Length ⅛th inch or a little less. Pl. VI, Fig. 7, depicts a dorsal and side view of this beetle.

Life History.

This small tomicid was taken plentifully at Kochugaon in the latter part of May. It tunnels down into the wood of fresh felled or sickly standing trees apparently laying its eggs deep down in the sap wood. The beetles were engaged in egg laying during the latter half of May.

21. XYLEBORUS sp.

Order—**Coleoptera.** Family—**Scolytidæ.**

Description.

Beetle.—Minute, golden-reddish in colour. Eyes simple funiculus 5-jointed club with 4 articulations in upper half. Thorax very convex, slightly longer than wide; base straight, anterior surface set with transverse scales, largest in front, posterior surface very finely punctate; elytra irregularly striate punctate, sloping at posterior end, declivous portion rugose and set with some prominent teeth. Under surface, antennæ and legs lighter coloured. Length $\frac{1}{8}$ inch. (See Pl. VI, Fig. 8.)

Life History.

This beetle was found in some numbers tunnelling into the sap wood of the Sal tree felled on the 13th May at Kachugaon. The beetles were mostly taken between 16th and 20th of that month. They were all found in the sap wood. I do not at present know whether they go down into the heart-wood or not. They evidently require absolutely fresh wood full of sap for their egg-laying operations.

22. PLATYPUS sp.

Order—**Coleoptera.** Family—**Platypodæ.**

Description.

Beetle.—Stout, robust, short, abruptly truncate posteriorly. Dark brown, apical half of elytra black and set with golden yellow stiff short hairs. Head sloped forward, puctate; club of antenna not articulate. Thorax a little longer than broad, with a prominent longitudinal median carina and scattered largish punctures. Elytra with well marked longitudinal rows of prominent punctures with smaller punctures between the rows. Under surface set with stiff short parallel yellow hairs. Anterior coxæ contiguous. Length slightly under $\frac{3}{16}$th inch. Pl. VI, Fig. 9, shows this insect. The curious short squat thorax and elytra give a characteristic appearance to this insect.

Life History.

This is a common beetle in freshly felled Sal trees in the latter half of May. It was taken in numbers from the green tree felled on 15th May and also from other felled green trees. In all cases it had attacked the trees after they had been felled. It was, however, also cut out of green sickly dying standing trees. The insect evidently only attacks green wood and is not to be found in dead wood.

The beetle was ovipositing in the latter half of May, the beetles then taken being probably those of the first generation of the year laying the eggs of a second. The egg gallery may go in through the bark at a slight angle, but on reaching the sap wood the beetle tunnels straight down into the heart-wood. There are no offset galleries to the main one, the eggs being laid at the bottom of this latter. The larvæ on hatching out of the eggs appear to feed upon fungi lining the walls of the egg gallery since in old tunnels examined there was no evidence of any larval gallery or tunnel eaten in the wood.

The beetle will attack the wood with the bark on or off, so that barking the felled tree is no protection against it. It enters a log with as equal facility at a cut end as by boring down through the bark. Its presence is easily recognisable as the particles of wood eaten out in making the gallery are pushed up the tunnel and ejected from the mouth of it either in the form of little heaps of saw-dust or, more usually, as little cylindrical wood masses which project upwards out of the bark. The colour of these cylinders will at once tell the observer how deep the beetle has got into the wood.

23. DIAPUS sp. (238—1906).

Order—**Coleoptera.** Family—**Platypodæ.**

Description.

Beetle.—Narrower than last, but of same length. Shining black. Elytra brown with the basal half greenish yellow. Eyes round. Thorax fairly deeply emarginate on sides, with a deep depression on either side anteriorly and prominent punctures along base, and very fine wavy lines medianly. Elytra punctate with longitudinal striæ placed far apart. The green portion is due to a covering of greenish yellow hairs, the surface beneath it being black. Length ⅛ inch. (See Pl. VI, Fig. 10.)

Life History.

This beetle was taken plentifully from the Sal trees felled during my stay in the Kachugaon Forests (*i.e.*, between 15th and 23rd May). The first specimens were taken on 15th May from the tree felled on the 13th of that month. It, like the last, tunnels into the wood of the tree entering either at the end of a log or through the bark. The hole made is of considerably smaller diameter than the last, and in this way its attacks can be distinguished on the outside from those of its companion, the little cylinders of ejected wood having a considerably narrower diameter.

24. DIAPUS sp.

Order—**Coleoptera.** Family—**Platypodæ.**

Description.

Beetle.—Minute. Ferrugineous brown or black, shining; elytra sometimes with yellowish patches on the median portion. Head punctate, thorax with very fine transverse striæ and posterior parts, the median area being smooth. Elytra with very strongly raised longitudinal ridges which starting from the base become stronger as they approach the apex and are prolonged into short curved hooks which project from the elytra at the point where the latter are declined downwards at apical end. A prominent spine projects from the median apical end of the elytra. This elytral armature is only present in the ♀, the apical ends of elytra in ♂ being truncate and straight. Length ⅛ inch. (See Pl. VII, Fig. 2.)

Life History.

This tiny platypid was very pentiful in the Kachugaon Forests in the latter half of May. Within 24 hours of a tree being felled it made its appearance and at once commenced to tunnel down into the wood, entering through the bark or at one end of the logs. It drills circular tunnels more or less straight, except at their commencement, into the sap wood. The insect infests both the main stem and the larger branches. This little beetle differs from most platypids owing to its great activity. Most of these insects have very long, slender weak tarsi and are quite unable to progress at all fast when out of their tunnels. This one, however, is able to run about over the Sal bark at a very rapid rate. It appears to only infest green wood and attacks standing green sickly trees as well as newly felled ones.

25. BRENTHUS sp. (235—1906).

Order—**Coleoptera.** Family—**Brenthidæ.**

Description.

Beetle.—Elongate, narrow, crimson red in colour with short, stout antennæ and long legs. Elytra with three or four prominent longitudinal striæ and a black spot about the middle. Thorax smooth. Elytra punctate. The insect appears to vary a great deal in size.

Length ¼ to ⅓ inch. Pl. VI, Fig. 11, shows a dorsal view of this beetle and Fig. 11*a* a piece of wood with a gallery in it made by the beetle.

Life History.

This beetle was cut out in some numbers from the wood of the main stem of a stag-headed green Sal tree felled on May 14th in the Kachugaon Forests. The beetle appears to bore circular tunnels through the bark and lays its eggs in these. I have not yet taken any larvæ.

The discovery of this beetle in this situation is of very considerable interest,* since practically nothing is known about the life histories of the beetles of this family. Many are thought to be predaceous, and it may be that the larvæ of this insect feed predaceously upon wood-boring larvæ. I think, however, that it is improbable and that they are true wood-borers.

Damage Committed in the Forest by the Scolytid, Platypid and Brenthid Wood-borers.

The damage committed by the above described scolytid, platypid, and brenthid beetles is almost entirely to the wood of the tree. Whilst some of them probably only attack the sap wood, others undoubtedly bore into the heart-wood of the tree. When very numerous they not only impair the value of the timber, but undoubtedly give considerable aid to the bark beetle species in killing sickly trees.

Protection.

Trap trees are recommended, but in the case of these insects it is essential to cut up and burn the whole of the tree when the beetles have finished laying in it, as the grubs and maturing beetles will not be in or beneath the bark but down in the timber itself.

Points in the Life History requiring further Observation.

At present we know very little about these wood-boring *Scolytidæ*. The periods of flight in the month of May have been ascertained, and it is probable that the beetles found on the wing at that period are those of the first generation of the year newly issued and intent on laying the eggs of a second generation. We have yet to learn—

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* I also cut out two pupæ from the wood of a fallen tree (*Pterospermum acerifolium*) in the evergreen forests on the Balipara reserve in North Darrang. One of these matured into a fair sized brenthid beetle of very handsome colouring.

(1) How the larvæ of the various species feed. Are they all ambrosia feeders, or do some of them feed upon the wood itself?

(2) Length of time passed in the larval stage.

How often do the beetles appear in the year, *i.e.*, how many annual generations of them are there?

INSECTS PREDACEOUS UPON THE SCOLYTID AND PLATYPID SAL-BORERS.

26. PLATYSOMA? sp. (247—1906).

Order—**Coleoptera.** Family—**Histeridæ.**

Nature of Attack.

This histerid is, I think, predaceous upon one or more of the Sal wood-borers, most probably upon the *Diapus* sp.

Description.

Beetle.—Smaller than one previously described. Black, shining compact, with black smooth thorax and striate elytra, the striæ far apart. Two posterior segments of the elytra are exposed. Pl. VI, Fig. 12, shows this beetle.

Life History.

Not common. It was taken from beneath the bark of the Sal tree felled on the 13th instant in the Kachugaon Forests. It was apparently engaged in entering the tunnels, probably for ovipositing purposes, of the wood-borers. *Diapus* sp. appeared likely to be the chief of its hosts.

27. HEMIPTERA (248—1906).

Order—**Hemiptera.** Family—

Nature of Attack.

This small hemipterous bug is predaceous upon the platypid *Diapus* sp.

Description.

Black. Head small, pointed anteriorly with short 4-jointed antennæ. Thorax convex punctate. Abdomen black; elytra membranous. Under-surface black; antennæ and legs crimson brown.

Life History.

This small bug was taken in company with the small wood-boring *Diapus* in the green Sal trees felled at Kachugaon. It appeared to be predaceous upon the platypids. It was also taken in slabs cut from trees felled last February.

CHAPTER IV.

IV.—INSECTS ATTACKING THE BAST LAYER AND SAP WOOD OF BRANCHES IN THE CROWN OF THE TREE.

28. GRYLLUS sp.

Order—**Orthoptera.** Family—**Gryllidæ.**

Nature of Attack.

Mr. Perrée had noticed in the Sal Forests of Goalpara, notably perhaps in the Guma Reserve, that occasionally the trees were subject to a curious thickening of the branches in their crowns. The tree under this infestation apparently ceases its growth in height and a number of branches of small diameter grow straight up out of the main stem showing this peculiar thickening. This curious method of growth was noticed by the Inspector-General of Forests during his tour in Assam in the cold weather of the present year, but up to the present its cause has remained unsolved. I am not yet prepared to say that the solution of this enigma is to be found either wholly or even in part in the attacks of the species of *Gryllus* here described; but from the observations made during the period I was able to give to the study of this curious infestation, it appears very probable that the habits of the cricket may be responsible to a considerable extent for the stoppage of height growth in the tree.

Previous Records of the Insect.

I know of no previous records on the life history of this insect. As I have only as yet seen the immature young stages bred from eggs, I am not at present able to identify the pest.

Description.

Egg.—Elongate, yellowish, shining. *Vide* Pl. VII, Figs. 3, 3 *a*, the latter magnified.

Immature cricket.—Slender, elongate, with long legs and very elongate setaceous antennæ. Bright yellow on leaving the egg, darkening to yellowish green afterwards. Fig. 3 *b* shows a young cricket just issued and Fig. 3 *c* one nearly a week old.

Life History.

The female insect apparently cuts out irregular patches and depressions in the bark and sap wood of the branches of the tree and lays eggs in bundles in the incisions. These eggs are placed side by side in semi-elliptical or circular masses in a position which is moreor less parallel to the long axis of the branch, Pl. VI, 3 *d*. At times the eggs are found one on top of the other, the whole mass forming a bundle, the long axes of the eggs being more or less parallel to one another. The bark outside round which sap is generally oozing has a withered and spongy appearance which is easily discernible on the living branch, and on removing it the translucent patches of eggs thus bunched together are peceivable in the white sap wood, Fig. 3 *d*. In depositing the eggs in this position the insect would appear to cut deep incisions down through the bark into the sap wood parallel and close together, the first laid eggs being placed deepest down in the wood. There is thus usually a thin layer of wood fibres covering the mass with bark above it. The infested places always form well-marked brownish decaying patches on the surface of the branch. It is by opening out such areas that the eggs are found. The eggs appear to be usually laid at the junction of a branchlet with the main branch or even that of a petiole of a leaf with its branchlet or at the base of a bud. This is not, however, invariably the case, as the patches are found on parts of the branch remote from the junction of other branches, buds, etc.

On hatching out the crickets are small, wingless, yellowish brown insects, about $\frac{1}{8}$th inch in length, the antennæ being of very great length. They are able to run with great rapidity on the bark and leave the place where the eggs were laid as soon as they hatch. From portions of branches taken in May 9th and kept under observation eggs hatched out on May 14h. Cluster of eggs appear to hatch out more or less at the same time.

It has not proved possible to carry the observations on the life history of this insect further, but the investigations carried out so far would seem to show that in their feeding operations the insects set up an irritation at the junction of the branches and elsewhere which gives rise to the peculiar growth.

Damage Committed in the Forest.

The damage committed in the crown of the tree is of a two-fold character. Firstly, the branches in the crown grow vertically upwards, and, secondly, they themselves may be uniformly thickened all round to double their ordinary size and terminate abruptly with no tapering at the top, a few stunted side branches being thrown out; or they may have curious lumpy excrescences usually at the junction of branches or where former branches had existed. In such case the interior woody structure is soft and rotten, though still green and full of sap. The branches affected can be broken off with ease. A closer inspection of the woody cortex of the rotten branches showed here and there irregular scars and depressions, either penetrating to the wood which was decaying or partially overgrown by new and later tissues. Sections cut across the swollen masses occasionally displayed series of irregularly arranged small decayed areas which originally formed the depressions in which the eggs were laid. Whilst the actual attack appears to be confined to the axis of branches or base of branchlets and petioles, etc., and to the wood immediately below the bark in the smaller branches, evidence of fresh attacks was found on the main portion of the branch. The rotten state of the larger branches appears to be due to the continuous feeding of several generations of the crickets, perhaps extending over several years, and to the rot and decay set up by this action. This agrees with Mr. Perrée's theory that the branches take several years to die under the attack. The thickening and local swellings and excrescences on the branches are the most characteristic feature of the attack.

The cause of the upward growth of the branches I attribute to the feeding of the insects at the base and below the junction of the branch, the irritation set up causing the branch to grow inwards and upwards.

Methods of Protection.

With the paucity of information at present available on this curious attack, if the peculiar growth is indeed due to the *Gryllus*, it is impossible to state yet what measures of prevention or diminution can be taken.

Points in the Life History requiring further Observation.

A perusal of the above notes upon the life history will show that much remains to be observed on the habits of this insect. We require to know—

(1) The period spent by the insect in reaching maturity.

(2) Its exact method of feeding during this time.

(3) The number of generations passed through during the year.

Points (2) and (3) are of very considerable importance.

29. ARBELA sp.

Order—**Lepidoptera**. Sub-Order—**Heterocera**. Family—**Arbelidæ**.

Nature of Attack.

This insect infests the tree in a manner somewhat similar to that of *Arbela tetraonis* in the Casuarina plantations on the east coast of Madras.* The caterpillar lives on the outer bark eating out patches of irregular shape which penetrate down into the sap wood. The large branches in the crown of the tree and main stem of poles are the portions infested.

Previous Records of the Insect.

I have been unable to discover that there are any records extant of the attack of this insect. The species infesting the Sal here is unknown to me. It may prove identical with *Arbela tetraonis*,† the latter insect having been described from the Khasia Hills by Swinhoe under the synonym *Arbela phaga*.

Description.

Pupa.—Resembles that of *Arbela tetraonis*. Yellowish brown to dark brown, the last segments or segment black, elongate, cylindrical in section. Thoracic end short and narrow; six well-marked circular abdominal segments below it, each segment with two transverse rows of spines placed close together near centre of segment. Pl. VII, Fig. 4 shows the pupa. Length 1¼ inches.

Life History.

Towards the middle of May a number of recently vacated empty pupal cases of this insect were discovered projecting from the bark (as shown in Fig. 4 *a*) of the branches of Sal trees felled before me in the Guma Reserve in Goalpara. The presence of these cases indicated that the flight period of the moth is sometime in April or at the commencement of May, and that the eggs are laid about that period on the

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* *Vide* my note on "the Casuarina Insect Pests of Madras," pp. 2—8, Indian Forester, Vol. XXIX, Appendix Series.

† Departmental Notes on Insects that affect Forestry, Vol. I, pp. 438—445.

bark. Since no young larvæ were discovered in the middle of May, it is probable that the eggs do not hatch before the burst of the monsoon, which this year (1906) was very late in arriving in this district. Evidences of old attacks of the past and previous years were, however, plentiful. The caterpillar lives on the bark of the tree eating out patches of irregular shape. These are sometimes shallow; at others they penetrate in roughly circular holes down to the sap wood. It is possible that the grub stays here during the day time or it may hide in the interstices of the thick bark of the tree since it does not build the long covered ways which are so characteristic of the attacks of *Arbela tetraonis* in the Casuarina. The covered ways made by this larva consist only of masses of silk and excreta found at the nodes of branches, and more especially in the fork. It may hide in these positions during the day time. It is certainly a night feeder, as, feeding exposed on the surface of the bark as it does, it would be very subject to the attacks of birds, etc., were it to feed during the day time. When full fed the caterpillar bores down into the wood, invariably selecting the junction of a branch for this purpose. The tunnel enters the wood either in the fork or at one side and is carried in at an angle, subsequently curving so as to run parallel to the long axis. The portion parallel to the long axis is elongate, elliptical, about 1½ to 2 inches in length and forms the pupal chamber of the grub. The curved entrance gallery to the pupal chamber is usually 1 inch to 1½ inches long. If a knot in the wood intervenes, the pupal chamber may be at an angle. When the moth is ready to emerge, the pupa works its way up the tunnel by means of the circular rows of spines present on the segments (see Fig. 4) and projects for about a half of its length from the branch.

Damage Committed in the Forest.

The method of feeding and pupation of this insect results in a twofold injury to the tree. In its feeding operations the grub destroys portions of the cambium layer, and in pupating it burrows into the wood forming tunnels. Neither of these injuries are of a particularly serious nature when they are confined to the large branches of the crown of the tree. It has been observed, however, that this insect also attacked poles in the forest. Consequently a bad infestation of the caterpillars would be a serious matter since it might result in the death of a large number of young trees. Similarly the tunnels bored down into the tree by the grub when about to pupate form a serious defect to the wood when they are made in the main stem of a pole. Should the tree not be killed, and this will be the case in the greater number of instances, the pupal chamber and tunnel will become enclosed by subsequent growths of wood until they become buried in the heart of the tree. Such buried and enclosed pupal chambers and tunnels were observed in the interior of the wood of several green trees felled. Although the actual width and length of one of these 'faults' would not in itself be sufficient to constitute a bad defect, when they are in any number they ruin the timber for large purposes.

Methods of Protection.

Until the full life history of this insect has been worked out it is impossible to say what would be the best means to employ to counteract a severe attack.

Points in the Life History requiring further Observation.

(1) The period of hatching of the eggs.

(2) Length of time passed in the larval stage.

(3) When the caterpillar pupates and length of time spent in the pupal stage. I think it probable that the cold weather months are spent as a pupa in the pupal chamber in the wood.

(4) Time of flight of the moth. Is it at the end of April and commencement of May only?

(5) Number of eggs laid by the moth and whether laid singly or in patches.

(6) Number of generations passed through by the insect in the year.

CHAPTER V.

V.—INSECTS DEFOLIATING THE LEAVES OF THE TREE.

30. CLANIA VARIEGATA.

Order—**Lepidoptera.** Sub-Order—**Heterocera.** Family—**Psychidæ.**

References :—Bland. *F. B. I.* Hamps. *Moths,* I, 291 (618).
Steb. *Injur.* (*Insects,* pp. 98-100 (1899).

Nature of Attack.

The caterpillar of this moth is known as a bag-worm from its habit of living in a case made of pieces of the bark and leaves of the tree. The grub lives entirely upon the leaves and occasionally causes heavy defoliation.

Previous Records of the Insect.

Mr. Dudgeon in 1891 first worked out, to some extent, the life history of this insect in the submontane forests of the Darjeeling District, this apparently being the first report extant of its existence in that locality, as Hampson only mentions it as an inhabitant of Southern India. The present is the first record I have of the presence of the insect in Assam. There is no evidence that it exists in the submontane Sal Forests of North-Western India or in the Central Provinces tract.

Description.

The various stages in the metamorphosis of this insect are described and figured (except the larva which I show in Pl. VII, Fig.5) on pp. 99-100 of my *Injurious Insects.* The larva when full grown is a robust caterpillar with a dark brown and shining head and mottled brown and black anterior segments. The segments which remain in the case through life, only some of which are exposed when the caterpillar is walking about, are lighter coloured and narrower. The prothoracic legs are long and stout. Considering the large size of the case the caterpillar is capable of fairly rapid movement.

Life History.

The caterpillar is to be found full grown and pupating in the latter half of May in Assam. Observations have shown, however, that the life cycles of this insect overlap and that both larvæ and pupæ are to be found throughout the rains. The insect was in considerable abundance this year in the Guma Reserve and elsewhere in Goalpara, and the trees showed a certain amount of defoliation from the attacks of the pest. The caterpillar is an erratic and wasteful feeder; it never entirely consumes a leaf before leaving it but after eating out portions here and there travels to fresh ones.

It is of some importance that the number of life cycles this insect passes through in the year should be ascertained and also the number of eggs laid by the wingless female within the larval case. The period spent by the larva feeding upon the leaves of the trees during each life cycle has also to be observed.

31. SUANA sp. PROX. CONCOLOR.

Order—**Lepidoptera.** Sub-Order—**Heterocera.** Family **Lasiocampidæ.**

Nature of Attack.

The caterpillar of this moth is a large hairy grub which feeds upon the leaves of the trees and at times commits serious defoliation in the forests.

Previous Records of the Insect.

I have no previous records of this insect. It has a superficial resemblance to *Suna concolor*, the caterpillar of which the moth defoliates the Sal in the Dun Forests.*

Description.

Larva.—Large, broad, flat beneath, convex above; of a general smokey greyish colour, greatly resembling sal bark, with lateral fringes of curious grey and white hairs which are spread out in small fan-shaped projections at their tips. Some short thick brushes of smoky grey hairs. Head smokey-grey, mouth parts small, yellow with brown markings and black mandibles, flat brushes of smokey-grey hair with white fan-shaped tips project on either side laterally and over the dorsal surface. Abdominal segments of a general smokey-greyish tint with a lateral black velvet longitudinal stripe on anterior segments and another on the usual ones. Medium segments 5, 6, and 7 with smaller X-shaped velvet stripes on anterior medium segments and a medium one projecting backwards at an angle from the medium

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Vide Departmental Notes, Vol. I, p. 58.

dorsal line behind these. The smokey grey tinge is interspersed with white and a faint greenish tinge in places, anteriorly, the latter being more marked posteriorly especially on dorsal surface of last segments which is flat and covered with white and green fine hairs. On segments 6, 7, and 8 a short brush of stiff greyish hairs above lateral line with very short longitudinal medium brushes on most of the segments dorsally. The lateral brushes of hair are beautifully arranged. They consist of short flat fan-shaped greyish brushes with a white fan tip to each hair. These brushes are longest on the head and first two thoracic segments being placed laterally on posterior base of each, and here consist of entirely white fan-shaped brushes with a black base. Projecting from these fan-shaped brushes are pencils of delicate greyish hairs of irregular shape each ending in a far tip greyish white in colour. The arrangement of these hairs is most beautiful and when in motion they are all held out distinct from one another and stiff. Interspersed amongst them are a few very fine smokey white hairs with simple tips. The brushes and long fan tipped pencil hairs are longest anteriorly, being shortest on the last segment from which they project backwards and outwards on either side. The prolays are black, stout, with strong claws curved inwards. The abdominal legs are long and stout, black with reddish markings, hairy with white clasper pads. Under surface blue-black, dull, but slightly hairy with a broad red lateral longitudinal band on each side spotted with smokey grey and projecting transversely on the thoracic segments. Length 2½". Breadth including hairy bunches ⅛". Pl. VII, Fig 6, shows this larva.

Life History.

The caterpillar of this moth occasionally appears in some abundance in the Goalpara Forests and seriously defoliates the Sal trees. I do not at present know when the eggs hatch, but the larva is full grown at the end of May and pupates at about that period. It spins a stout silken cocoon covering before changing to the pupal state. I have no further data about the insect. The caterpillar when at rest on Sal bark is such an exact imitation of it that it is most difficult to distinguish at any distance.

I have not yet been able to procure specimens of the moth, and until this has been done and we have ascertained when the eggs are laid, the number of generations in the year (probably not more than one), and its general abundance, it would be useless considering measures to adopt against it.

32. DASYCHIRA HORSFIELDI, Saund.

Order—**Lepidoptera.** Sub-order—**Heterocera.** Family—**Lymantriidæ.**

References.—Saund. Trans. Ent. Soc. n. s. i, 1851, p. 162. Hampson. Bland. Fam. Br. Ind. Moths. I. No. 999. *Dasychira frotei,* Moore Lep. E. I. Co., p. 338. *Dasychira kausalia,* Moore P. Z. S. 1879, p. 401. *Dasychira arga,* Moore Lep. E. I. Co., p. 139. *Dasychira nilgirica,* Hampson. Ill. Het. viii, p. 58, Pl. 141, Figs. 13, 14. (Departmental Notes, Vol. I, p. 63.)

Nature of Attack.

The caterpillar of this moth is one of the heaviest defoliators of the Sal Forests of Assam.

Previous Records of the Insect.

Considerable difficulty has been experienced in settling the question as to which are the principal Sal defoliators in Assam. In the attacks reported by Messrs. W. R. Fisher and Campbell an insect, doubtfully identified as *Dasychira thwaitesi,* was said to be one of the chief offenders in the Goalpara Forests. I have now taken an identified *D. horsfieldi,* which is one spread throughout India, Burma, and Ceylon, in these same forests, whereas *D. thwaitesi* according to Hampson has only been reported from Ceylon. At present therefore appearances appear to be in favour of *D. horsfieldi* being the true *Dasychira* defoliator in the Assam Sal areas.

Description.

Larva.—Yellow with tufts of long yellow hairs on the body; shorter thick dorsal tufts of hair on the 4th to 7th and the 11th segments. Between the 4th and 5th segments there is a black dorsal patch.

Moth.—♂ head and thorax whitish grey, the branches of the antennæ being red-brown; abdomen orange with the anal-tuft grey; legs spotted with black. Fore wing greyish-white, irrorated with dark scales and slightly suffused with brown crossed by some irrregular, diagonal and straight zig-zag black lines. Hind wing pale, the inner area orange; a more or less prominent dark spot near centre of upper edge. Underside with prominent spots on both wings.

♀ head thorax and fore wings white, slightly greyish, the latter with some indistinct lines. Abdomen and hind wing pure white.

Expanse of wing; ♂ 46 ♀ 70—86 within. Pl. VII, Fig. 7, shows the female moth.

Life History.

The moth was taken on the wing in the Borobadha forest on May 10th. I saw no larvæ at the time of my visit and have therefore nothing further to add to the notes recorded under *Dasychira* sp. (which I believe to be this insect) in *Departmental Notes*, Volume I, p. 63. The insect would appear to pass through at least four generations in the year, appearing between August and May. It is not improbable that there is yet another generation between May and August. This point requires further and early observations in order to enable it to be satisfactorily settled.

33. LYMANTRIA MATHURA, Moore.

Order—**Lepidoptera**. Sub-Order.—**Heterocera**, Family—**Lymantriidæ**.

References:—Departmental Notes, I, pp. 67-77.

Nature of Attack.

The caterpillars of this and the following two moths (*Lymantria lepcha* and *L. bivittata*) are amongst the chief defoliators of the Sal in the submontane and Duars Sal tracts of Eastern Bengal and Assam.

Previous Records of the Insect.

I have already recorded the presence of *Lymantria mathura* and *L. bivittata* in *Departmental Notes*. *L. lepcha* has only previously according to Hampson been reported from Sikkim. I took it in the Borabadha forest, Goalpara.

Description.

It will be unnecessary here to describe *L. mathura*, a description of which is given in *Departmental Notes*, Vol. I, p. 67. Pl. VIII, Fig. 1, shows the female of this insect.

34. LYMANTRIA LEPCHA, Moore.

Order—**Lepidoptera.** Sub-Order—**Heterocera.** Family—**Lymantriidæ.**

References :—Moore, Lep. Atk. p. 54 ; C. & S. No. 1025 ; Hampson Bland. F. B. I. Moths No. 1042 *Barhona Carneola* Moore Lep. Atk. p. 56.

Description.

Moth.— ♂—Head and thorax white ; the line behind the head crimson ; thorax with black spots ; abdomen white, with a slight crimson tinge. Fore wing ochreous white with a crimson spot at base on the costa and four equidistant lunulate lines. Hind wing whitish ; the basal and inner areas tinged with crimson and a faint marginal band. ♀—Pale pink ; antennæ, palpi and legs black ; the first joint of antennæ and line behind the head crimson, a line and two lunular marks on the wing.

Expanse of wing ♂ 62, ♀ 2 to 98 millim. Pl. VIII, Fig. 2, shows the ♂ of this insect.

35. LYMANTRIA BIVITTATA, Moore.

Order—**Lepidoptera.** Sub-Order—**Heterocera.** Family—**Lymantriidæ.**

Reference :—Departmental Notes Vol. I, p. 71.

The description of this insect is given on p.71 of volume I of *Departmental Notes.* Pl. VII, Fig. 8, shows this insect.

Life History of the Lymantria Insects.

I have dealt fully with the life histories of these *Lymantria* insects as far as at present known in the *Departmental Notes.* Unfortunately for my purpose the insects were by no means plentiful in the forests during my visit in April and May. The caterpillars appear to be most active between October and November and the end of March.

A specimen of a *Lymantria* was taken in the middle of April in a small outlying patch of Sal which lies to the north of the Charduar rubber plantation in the Darrang District. Specimens of *L. mathura*, *L. lepcha* and *L. bivittata* were also taken sparingly in the Borobadha and Kachugaon Forests in the latter half of May. The moths were taken and a certain number of pupæ in cocoons spun on to Sal leaves.

Pl. VII, Fig. 9, shows one of the Lymantriid larvæ, and Fig. 9 a one of their hairy pupæ of which the following is a description:—

Stout, black, shining, this terminal segment is constricted to a point. Thoracic portions dull black. The abdominal segments are clothed with long silky white hair forming pencils and brushes of considerable thickness on the terminal segments. Length one inch, breadth, ¼ inch. (See Fig. 8 *a*.)

36. ASPHINGIDÆ LARVA.

Order—**Lepidoptera.** Sub-Order.—**Heterocera.** Family—**Spingidæ.**

A few species of this caterpillar which is shown in Pl. VII, Fig. 10, were taken upon the Sal trees at Kuchugaon. The insect is a Sal leaf defoliator, but was not found in any abundance. Nothing more at present known about its life history.

A PARASITE ON A DEFOLIATING CATERPILLAR.

Order.—**Hymenoptera.** Family.—**Chalcididæ**

37. CHALCIS ? sp.

This insect was taken from a cocoon of a Sal defoliating caterpillar in the Guma Reserve, Goalpara, on May 10th. The fly issued on May 13th.

Description.

Cocoon.—Compact, elliptical, consisting of a stiff papery material covered with short interwoven hairs.

Imago.—Black with greatly enlarged posterior femora and canary yellow tibiæ and tarsi and anterior femora. Pl. VIII, Fig. 3, shows this insect.

CHAPTER VI.

VI.—INSECTS TUNNELLING IN AND DESTROYING THE TWIGS AND BUDS.

38. MICROLEPIDOPTERA.

Order—**Lepidoptera.** Sub-Order—**Heterocera.** Family—**Microlepidoptera.**

Nature of Attack.

The small caterpillar of this moth tunnels in the smaller twigs, base of petioles, and the buds, completely hollowing them out and destroying them.

Previous Records of the Insect.

There is no previous record of the attacks of this insect on the Sal.

Description.

Larva.—Minute, elongate, yellow or semi-translucent with a brown head; three pairs of thoracic legs and five pairs of abdominal ones. The last two segments are a dirty white in colour.

Pupa.—Small, elongate, brownish in colour, pointed posteriorly.

Life History.

The egg is evidently laid by the moth on the unopened bud or at the base of the petiole or small twig. The young caterpillar on hatching out bores into the bud, petiole, or twig, and entirely eats out all the interior tissue (see Fig. 4, Pl. VIII). The outer parts turn brown, and in the case of a bud or leaves they fall to the ground. The grub would appear to leave the bud, etc., when it has entirely hollowed it out and enter a fresh one or a twig, etc. The caterpillars are full grown in the middle of May and pupate *in situ* in the bud or twig near an exit hole previously bored to enable the moth to escape. The pupal stage lasts some fourteen days and the moth then appears. It is probable that this insect passes through several life cycles in the year.

Damage Committed in the Forest.

The importance of this insect in the forest cannot be accurately gauged at present. It was discovered in some abundance in the crowns of green trees felled in the Guma Reserve, and was also found in saplings. As a bud and small twig miner it has the power of committing serious damage should it ever become numerous in plantations or even in larger areas.

CHAPTER VII.

VII.—INSECTS TUNNELLING INTO AND DESTROYING THE SEED.

39. XYLEBORUS sp.

Order—**Coleoptera**. Family—**Scolytidæ**.

Nature of Attack.

The grub of the beetle feeds in and riddles the interior structure of the seed which decays and falls prematurely.

Previous Records of the Insect.

It has often been noticed and commented upon by those travelling through or living near tracts of Sal Forest in parts of the country that minute brown beetles are extremely plentiful in the cold weather months, especially January and a portion of February. I have seen them plentifully year after year in the Chota Nagpur Sal areas, and Mr. Perrée informs me that they are equally plentiful in Goalpara. These insects are everywhere and get into the food, being often found inside loaves of bread, etc. It has been surmised that they come from the flour of which the bread was made. The insect is a minute scolytid, and is, I think, the species found this year in Sal seed. There is no previous record of a beetle of this nature infesting the seed of this tree.

Description.

Larva.—Minute, white, curved, legless, with the segments corrugated.

Beetle.—Oval, elliptical, convex. Thorax blackish brown, elytra reddish brown and lighter coloured, the apical third set with a whitish yellow spiny pubescence. Thorax constricted in front; set with large transverse scales anteriorly those on the posterior half being smaller and finer. Elytra widest at the apical end where they are wider than the thorax; apical declivity slopes gradually. Under surface punctate; legs and antennæ yellowish-brown. Length $\frac{3}{32}$ inch. Pl, VIII, Fig. 5, shows a dorsal and side view of this insect.

Life History.

Specimens of the beetle were first cut out of fallen Sal seed in the third week of May.

The egg is laid in or near the flower and the young grub mines into the newly forming seed and remains feeding upon the seed substance until full grown when it pupates within the hollowed-out seed case. Pl. VIII, Figs. 5*a*, 5*b*, show the damage done to the seed by the grubs. On maturing the beetle bores a round hole through the seed skin and escapes. The eggs probably hatch out about March, the grub maturing at the end of April or first week in May. Beetles were cut out of seeds on May 21st. The insect would not appear to have been very abundant this year. From a basket full of seed examined only six mature beetles were taken, each in a separate seed. It is possible, however, that the time of issuing had not arrived.

40. CONOGETHES sp.

Order—**Lepidoptera.** Sub-Order—**Heterocera.** Family—**Pyraustidæ.**

Nature of Attack.

The caterpillar of the moth feeds in and riddles and destroys the interior structure of the ripening seed which drops prematurely.

Previous Records of the Insect.

I have no previous record of this pest.

Description.

Larva.—Elongate, dull, blackish, translucent, with a brown head.

Pupa.—Yellowish brown, thick, bluntly pointed posteriorly.

Moth.—A slender fragile moth with pale yellowish, narrowish wings marked with faint transverse pinkish, narrow lines. Pl. VIII, Figs. 6, 6*a* show larva and moth.

41. LASPEYRESIA sp.

Order—**Lepidoptera.** Sub-Order—**Heterocera.** Family—**Epiblemidæ.**

Larva.—Small, dull yellow. Smaller than last.

Moth.—Small slender fragile with yellow narrow wings marked with faint transverse pinkish lines. Fig. 7 shows this insect.

42. CACŒCIA sp.

Order—**Lepidoptera.** Sub-Order—**Heterocera.** Family—**Tortricidæ.**

Nature of Attack.

This insect lives in the same position as the last, and its attack is the same.

Previous Records of the Insect.

I am not aware that the attacks of this insect have been ever previously reported.

Description.

Larva.—Yellowish, translucent, elongate, slender, with a yellow shining head and 12 segments. Sixteen legs are present.

Pupa.—Small, slender, yellow, pointed posteriorly.

Moth.—Small, squarish, with a short rather thick body and truncate upper wings. Black in colour. Figs 8, 8*a* show the larva and moth.

Life Histories of the Heterocerous Insects.

The caterpillars of these two moths feed in a manner similar to that already described for the beetle grub. In May and June 1906 they were very much more numerous than the latter. The seed is completely hollowed out by the grubs. Only one grub occupies one seed and it increases in size with the growth of the latter. Green immature infested seeds were examined on the 9-11th of May. It was found that the grub which was then about half-grown or less fed inside the hard outer coats of the seed consuming the radicle and forming cotyledons. There is often a round hole on one side of the seeds and, if still green, a grub will be found in them. This would seem to show that the grubs on finishing one seed leave it and bore into another. The eggs are probably laid near or on the inflorescence panicles. The larva on hatching out crawls to and tunnels into the young ovule and feeds on it in such a way that its growth is not stopped until it has nearly reached full size, or the seeds attacked by the young larva may be killed, and the latter then leaves them and bores into uninfested half or nearly full-grown ones. The attacked seed turns from a brilliant green to brown and then black, and falls to the ground. At least one of the two grubs infesting the seed, probably the Pyralid one, leaves it when full-grown and pupates in the soil. Infested seed was placed in a box according to directions given by Rama Nath Mukerjee on May 31st. The larvæ were full grown at the time and the Pyralid ones left the seed and entered the layer of soil placed at the bottom of the box to pupate. The larva spins a silky cocoon covering in the soil before changing to the pupal state. The first moth issued on the 12th and others between this date and the 16th, on which date the observations were closed and all specimens sent to me. This would give 10 to 15 days as the length of time passed as a pupa.

A large number of fallen seeds were examined on 20th May. The grubs were mostly about three parts grown. Much of the seed was quite hollow, the grubs having left it. The life history from the middle of June to March in the following year when the Sal again flowers has yet to be observed. It is not improbably passed in the egg stage.

Damage Com mitted in the Forest by the three Seed-miners.

The damage done by all the three grubs is of a very similar nature. Under the attacks the seed is completely destroyed. Pests of this kind require very careful study since there can be little doubt that one of the reasons, and probably the chief one, why there is so little reproduction in many of the forests under fire protected management is due to the immense increase in the numbers of these pernicious seed-attacking insect pests. Before the introduction of fire protection, fires overran wide extents of forest-covered lands, these fires often occurring at the period of maturity of the seed or just before. In this way insects living in the manner of these Sal pests were burnt off in large numbers since at the time of the fire they were either in the seed on the ground or had left it to pupate in the soil.

There can be little doubt that these seed destroyers are increasing to a serious extent in fire protected forests.

Methods of Protection.

In case of severe attacks of these pests in areas where natural regeneration is urgently required, I would recommend the use of fire, When a severe attack is in progress a careful watch should be kept over the area affected, and when the maximum number of infested seeds have fallen to the ground the undergrowth should be fired. In Assam this period would be about the first week or so in June. This firing would kill off large numbers of the pests and would thus enable the next year's crop of seed to reach maturity. This suggestion could fall in with the experiments now being conducted by Mr. Perree in firing areas to get rid of the dense undergrowth, grass, etc., with the object of obtaining natural regeneration.

Points in the Life History requiring further Observation.

The following points still require study:—

(1) The exact period or periods and the place where the eggs are laid.

(2) In what stage of life is the period between the middle or end of June and the end of the following March passed in?

(3) Is there more than one generation in the year? If so, where is it passed and on what do the later grubs of the year feed?

A POSSIBLE PARASITE UPON THE SAL SEED DESTROYERS.

43. HYMENOPTEROUS GRUB.

I am not sure at present whether this grub is parasitic upon the larva of the beetle and moth Sal seed pests, or whether it actually feeds itself upon the interior structure of the seeds. I have taken as many as 12 grubs from the interior of one seed. This seed was hollowed out in a manner similar to those occupied by the beetle and moth grubs, and it may have been so treated by one of these latter grubs, the hymenopterous larva having fed parasitically upon it and finally killed it.

The hymenopterous grubs are very hardy, and deserted the seed and crawled about the inside of the tube they were placed in, remaining alive for over thirty hours after leaving the seed. They appeared to be full-grown.

Larva.—Minute, of usual hymenopterous shape. Head fine, pointed; rest of body much broader than head, corrugated, brilliant orange, tapering bluntly posteriorly. Length about ⅛ inch. Pl. VIII, Fig. 9 shows this insect.

G. I. C. P. O.—No. 996 R. & A.—4-10-1907.—600.—J. M.

PLATE I.

FIG. 1.—Eggs of Hoplocerambyx spinicornis.
  1a. An egg magnified.
  1b. Empty egg skin.
  1c. Young larvæ.
  1d. Larva 4—5 days old.
  1e. Young larval galleries in sap wood.
  1f. Gallery of ¼" larva in sap wood.
FIG. 2.—Cocoon of Ichneumon sp.
  2a. Imago.
FIG. 3.—Pupal skin of Bothrides sp.
  3a. Bothrides sp.
  3b. Shrivelled skin of Hoplocerambyx larva, from which the Bothrides beetle was bred.

PLATE II.

Portion of a trunk of a sal tree showing the work of the grubs of Hoplocerambyx spinicornis in the cambium and sap wood. Living larvæ are shown *in situ* in their galleries.

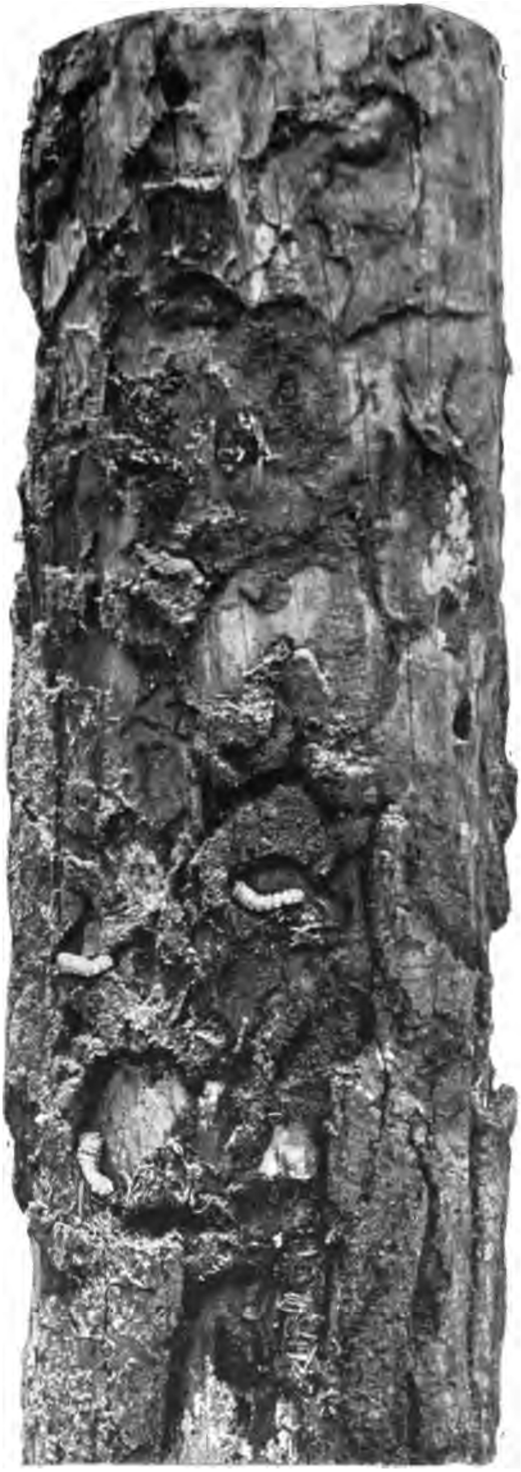


Photo-Mechl. Dept., Thomason College, Roorkee.

PLATE III.

Section of stem of a sal tree badly infested by Hoplocerambyx spinicornis. Living beetles are shown *in situ* in the pupal chambers which are closed by the white calcareous coverings.

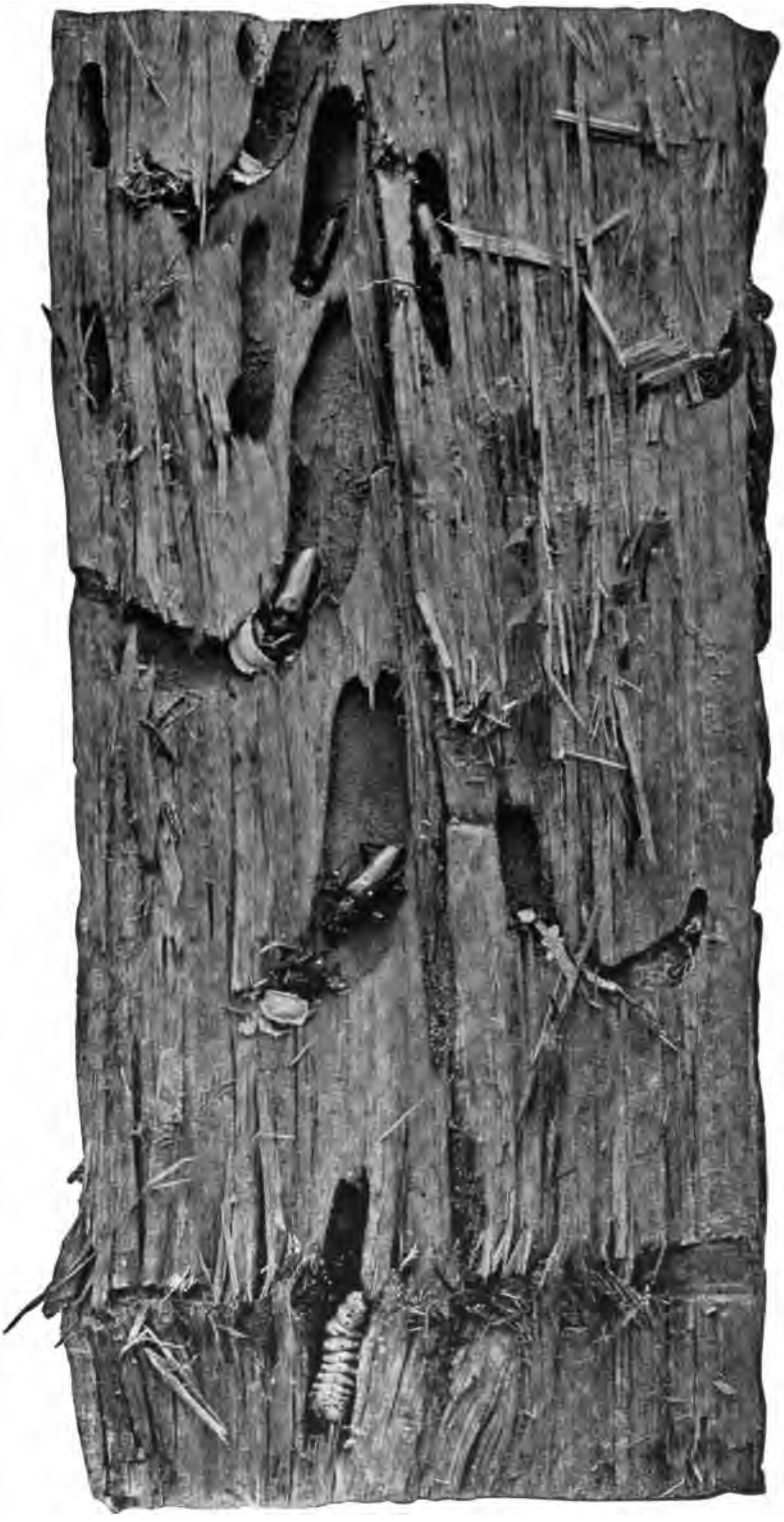


Photo-Mech. Dept. Thomason College, Roorkee. **hoto W. F. Perrée I. F. S.**

PLATE IV.

Portion of a living sal tree infested by Hoplocerambyx spinicornis showing the holes made by woodpeckers in the bark and wood to get at the grubs and pupæ.

Plate IV

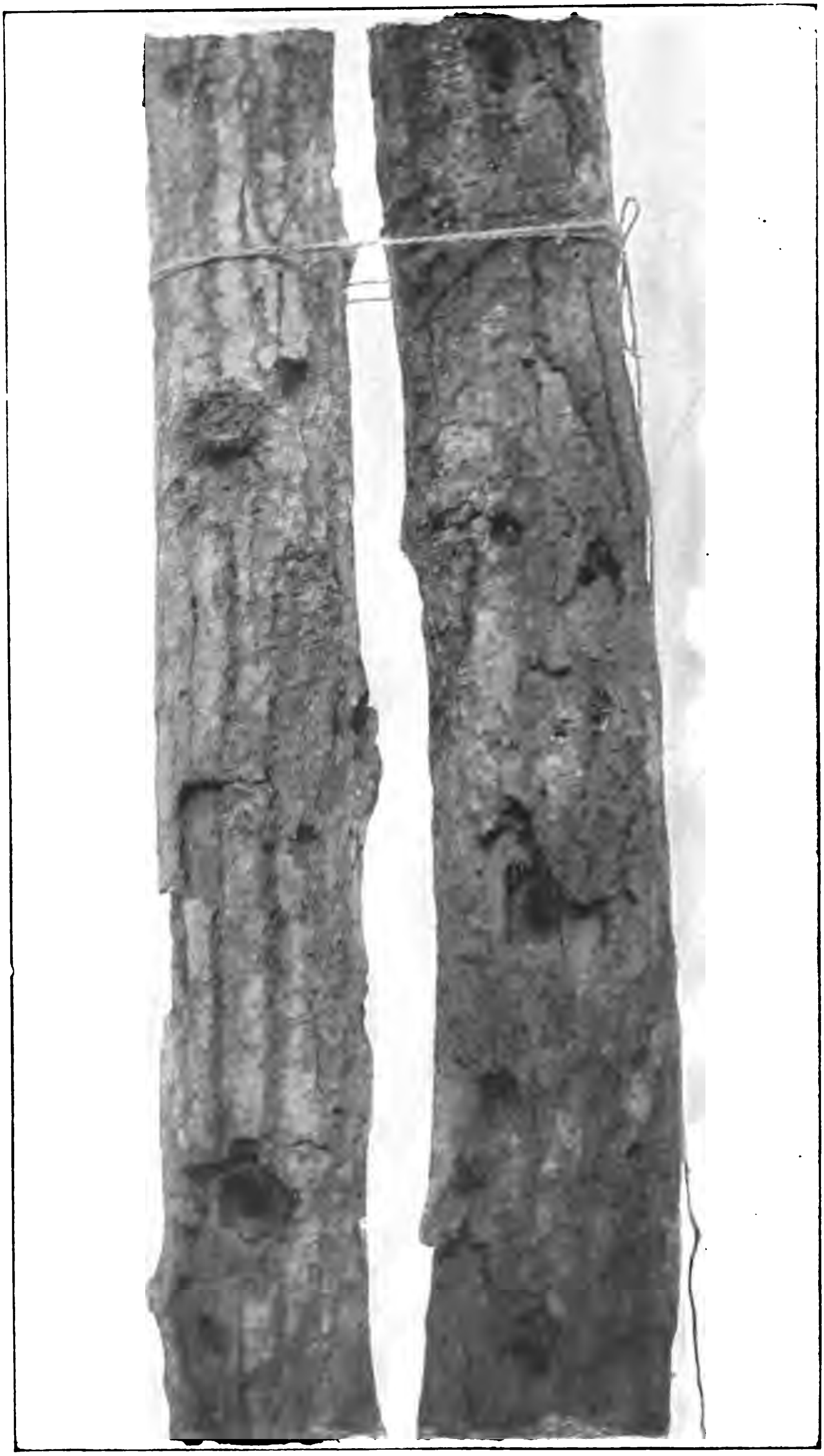


Photo-Mechl. Dept., Thomason College, Roorkee.

ATTACK OF WOOD PECKER.

PLATE V.

FIG. 1.—Dialages pauper—small larva.

1*a*. Full grown larva.

1*b*. Beetle.

FIG. 2.—Ichneumon sp.—cocoon.

2*a*. Fly.

FIG. 3.—Caloclytus sp. near Signaticollis.

FIG. 4.—Thysia Wallichi.

FIG. 5.—Larva of Sphærotrypes assamensis, n. sp.

5*a*. Pupa of ,, ,, ,,

5*b*. Beetle of ,, ,, ,,

5*c*. Pairing chambers in bark and sap wood.

5*d*. Egg and larval galleries made in green sal wood.

FIG. 6.—Pupa of Niponius Andrewesi.

FIG. 7.—Thanasimus assamensis, n. sp.

FIG. 8.—Platysoma sp.

Plate V

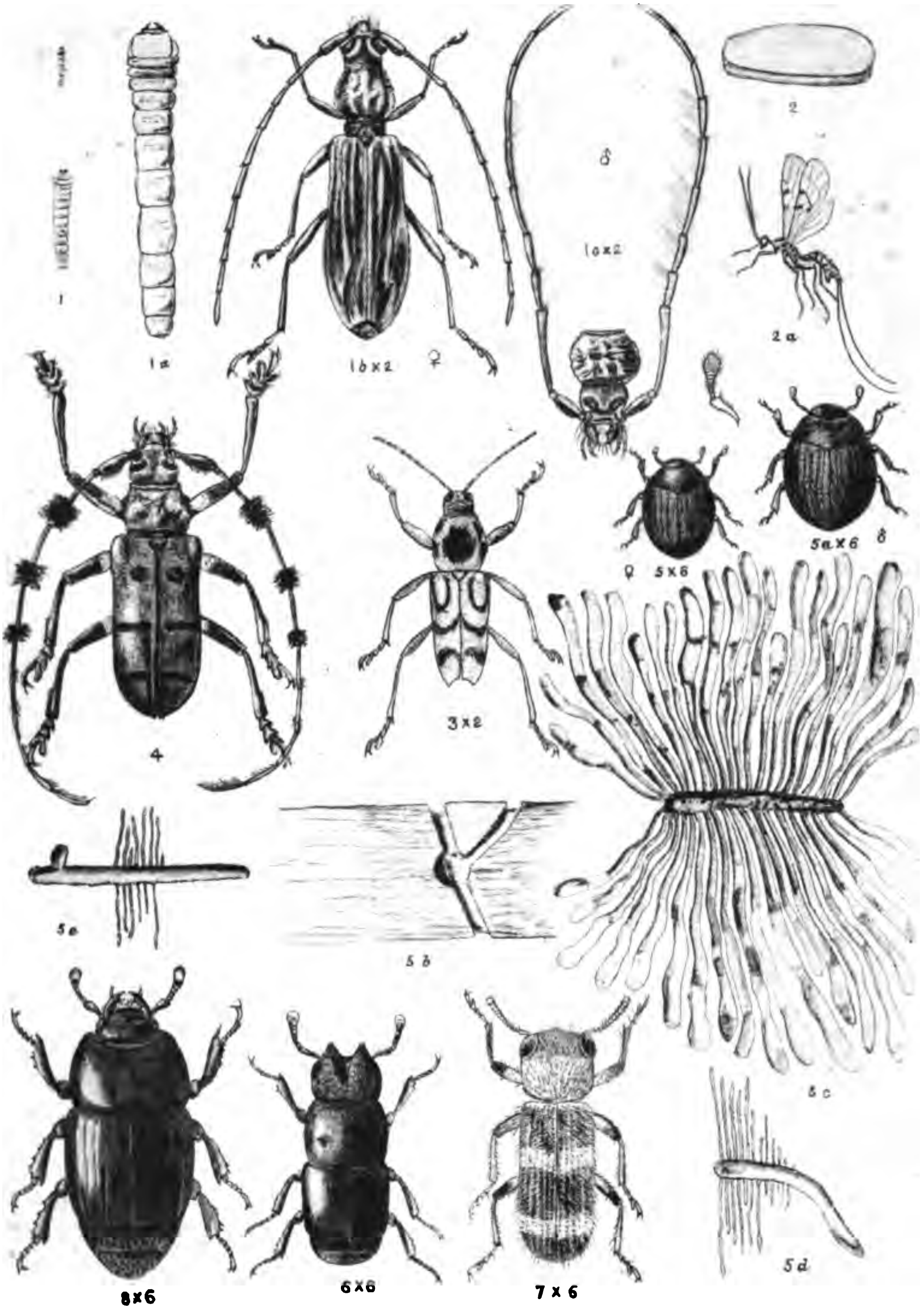


PLATE VI.

Fig. 1.—Larva of Cerambyx sp.

1a. Section of stem of a sal tree showing larval gallery in heart wood.

Fig. 2.—Side view of Phlœosinus major, n. sp.

2a. Dorsal view of do.

2b. Borings in sal wood made by do.

Fig. 3.—Dorsal and side view of Phlœosinus minor, n. sp.

Fig. 4.—Do do Dryocetes sp.

Fig. 5.—Do do Tomicus Shoreæ, n. sp.

Fig. 6.—Do do Tomicus sp.

Fig. 7.—Do do Acanthotomicus truncatus, n. sp.

Fig. 8.—Do do Xyleborus sp.

Fig. 9.—Do do Platypus sp.

Fig. 10.—Do do Diapus sp.

Fig. 11.—Do do Brenthus sp.

Fig. 11*a*. Piece of sal wood with a gallery of Brenthas sp. in it.

Fig. 12.—Dorsal view of Platysoma sp.

1. Cerambyx sp.
2. Phloeosinus major n. sp.
3. Phloeosinus minor n. sp.
4. Dryocetes sp.
5 Tomicus shoreae n. sp.
6. Tomicus sp.
7. Acanthotomicus truncatus n sp.
8. Xyleborus sp.
9. Platypus sp.
10. Diapus sp.
11. Brenthus sp
12. Platysoma sp.
13. Hemiptera.

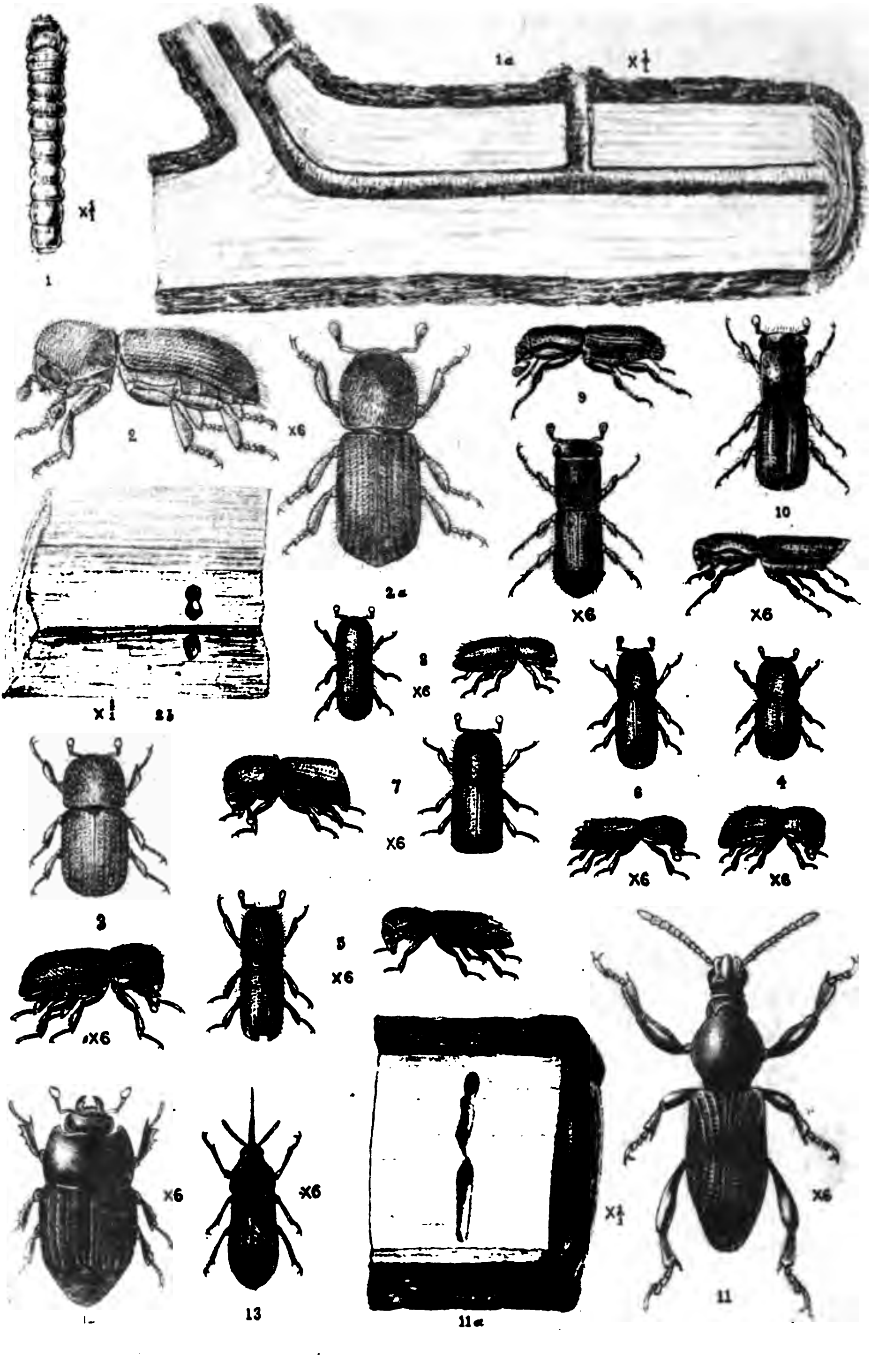

1
×1/1
1a
×1/1
2
×6
2a
×1/1
2b
9
10
×6
×6
8
×6
6
4
7
×6
×6
×6
3
×6
5
×6
×6
×6
×6
×6
1–
13
11a
×1/1
11

PLATE VII.

FIG. 1.—Dolurgus sp. (244-1906).
FIG. 2.—Diapus sp. (239-1906).
FIG. 3.—Cluster of eggs of Gryllus sp.
 3*a*. An egg magnified.
 3*b*. Newly hatched cricket.
 3*c*. Cricket nearly a week old.
 3*d*. Clusters of eggs as laid by cricket in sap wood beneath the bark.
FIG. 4.—Pupa of Arbela sp.
 4*a*. Pupa projecting from opening in the bark of a branch.
FIG. 5.—Full grown larva of Clania variegata in the case made of portions of sal leaves.
FIG. 6.—Full grown larva of *Suana* sp. prox *concolor*.
FIG. 7.—Dasychira horsfieldi, ♀ moth.
FIG. 8.—Lymantria bivittata moth.
FIG. 9.—Larva of a Lymantria sp.
 9 *a*. Pupa of do.
FIG. 10.—Sphingid larva.

1 Doburgus sp.
2. Diapus sp.
3. Gryllus sp
4. Arbela sp.
5. Clania variegata

6 Suana sp
7. Dasychira horsfieldii
8. Lymantria bivittata
9. Lymantriid larva
10. Sphingid larva

Plate VII.

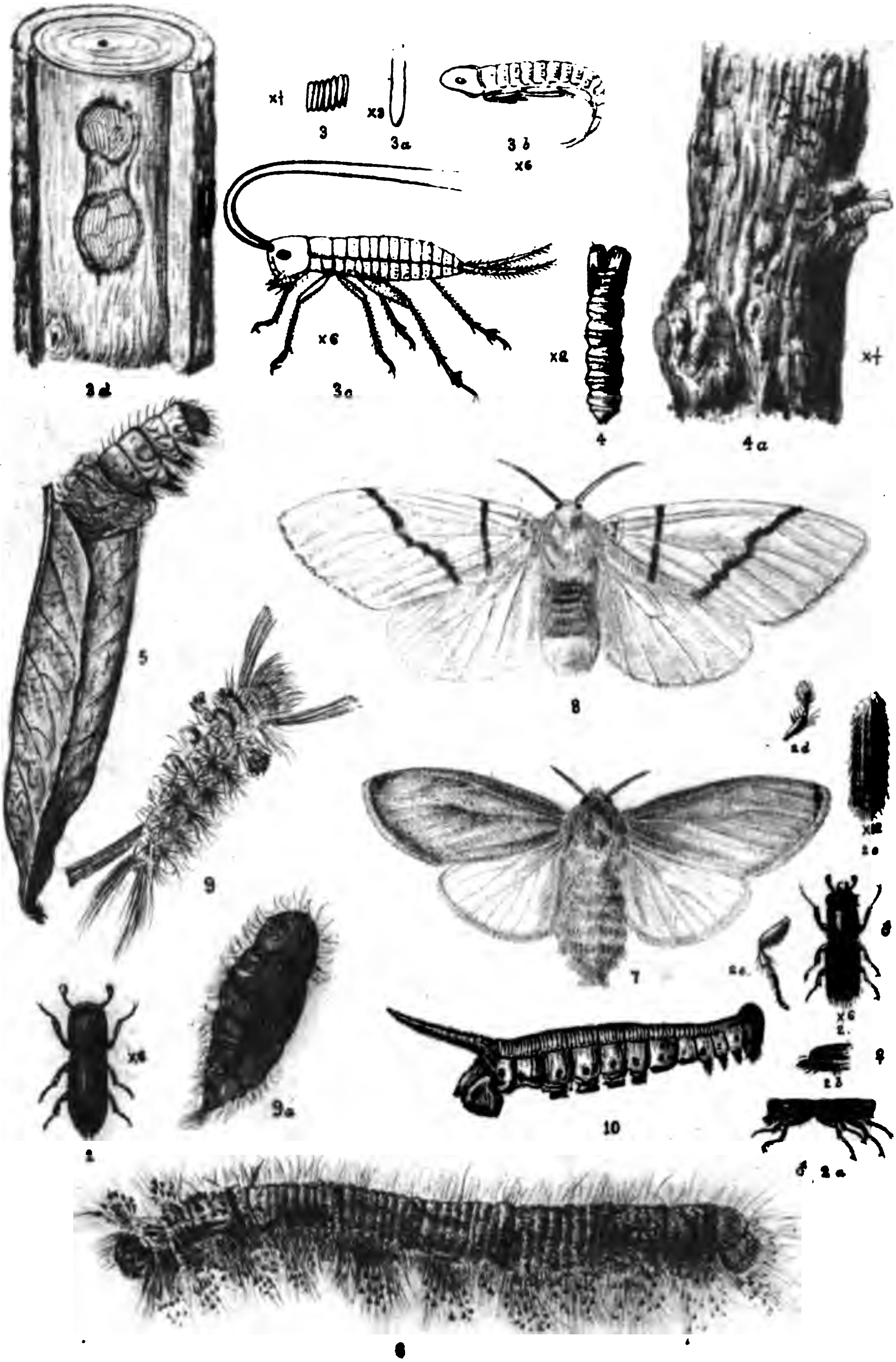
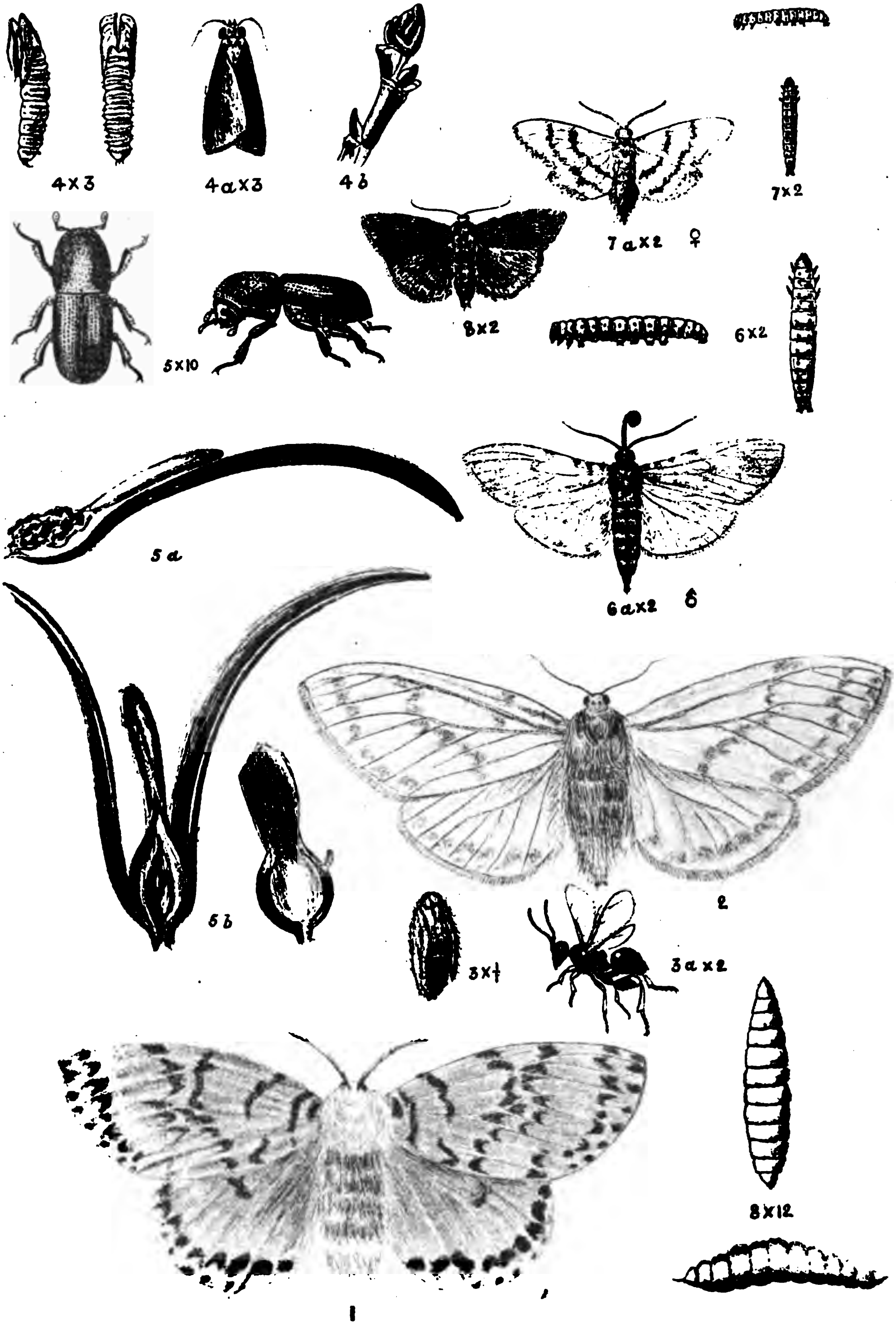

x¼
3
x3
3a
3b
x6
2d
x6
3c
x2
4
x¼
4a
5
8
2d
x12
2e
9
7
2c
♂
x6
2.
x6
2
9a
10
2b
♀
♂ 2a
6

PLATE VIII.

FIG. 1.—Lymantria mathura, ♀ moth.
FIG. 2.—Lymantria lepcha, ♂ moth.
FIG. 3.—Chalcis sp. imago.
3*a*. Pupa from which fly issued.
FIG. 4.—Microlepidopteron pupa.
4*a*. Moth.
4*b*. Sal twig tunnelled by the larva.
FIG. 5.—Xyleborus sp., dorsal and side view.
5*a*. Section of a sal seed showing interior completely riddled and killed by the grubs of the beetle.
5*b*. Sal seeds infested by grubs of beetle.
FIG. 6.—Cognogethes sp. larva.
6*a*. Moth.
FIG. 7.—Laspeyresia sp.
FIG. 8.—Cacœcia sp. larva.
8*a*. Moth.
FIG. 9.—Hymenopterous grub found in sal seed.


4×3
4a×3
4b
7a×2 ♀
7×2
5×10
8×2
6×2
5a
6a×2 ♂
5b
2
3×½
3a×2
8×12
1

3 2044 102 808 086

J. H. HOLZER BINDER BOSTON MASS.